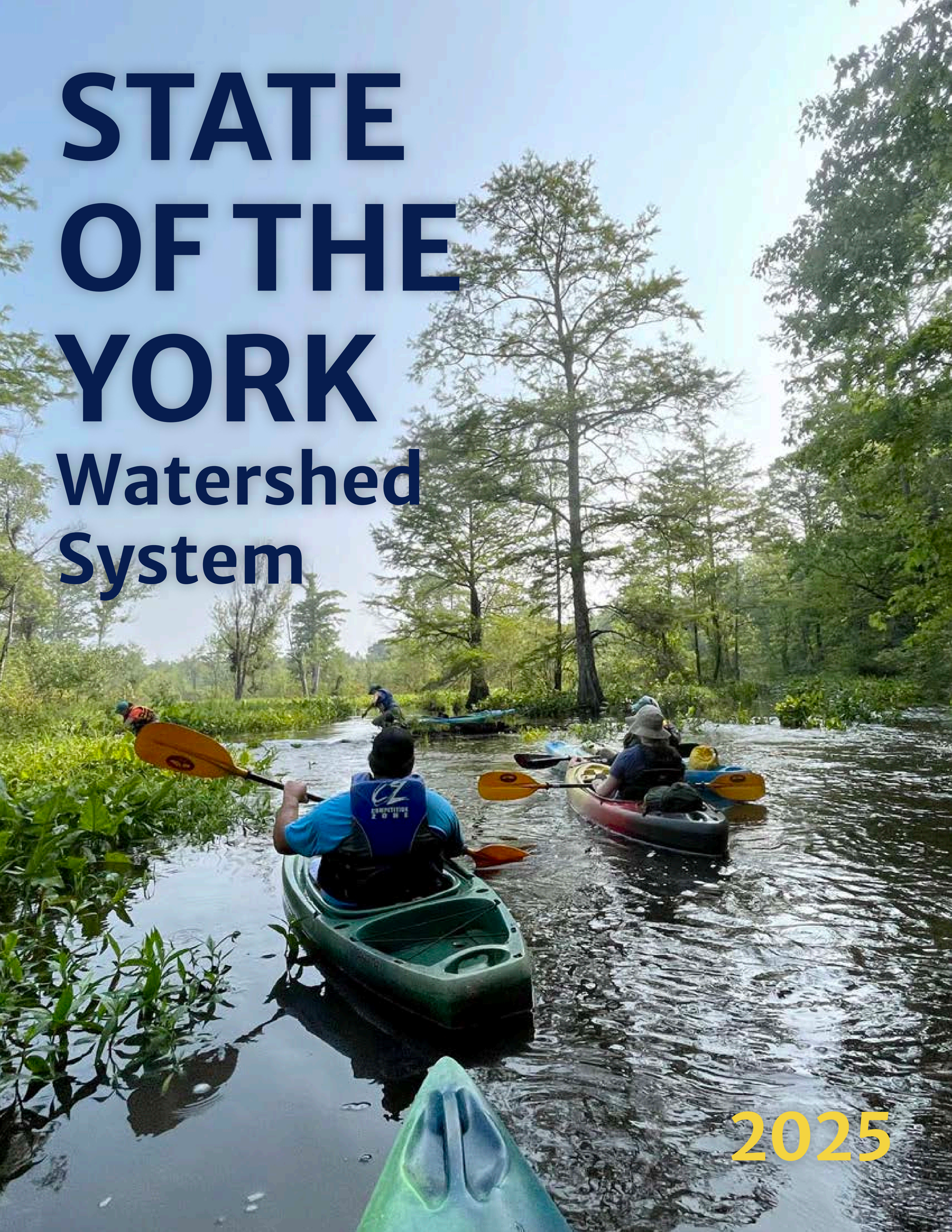
STATE OF THE YORK Watershed System

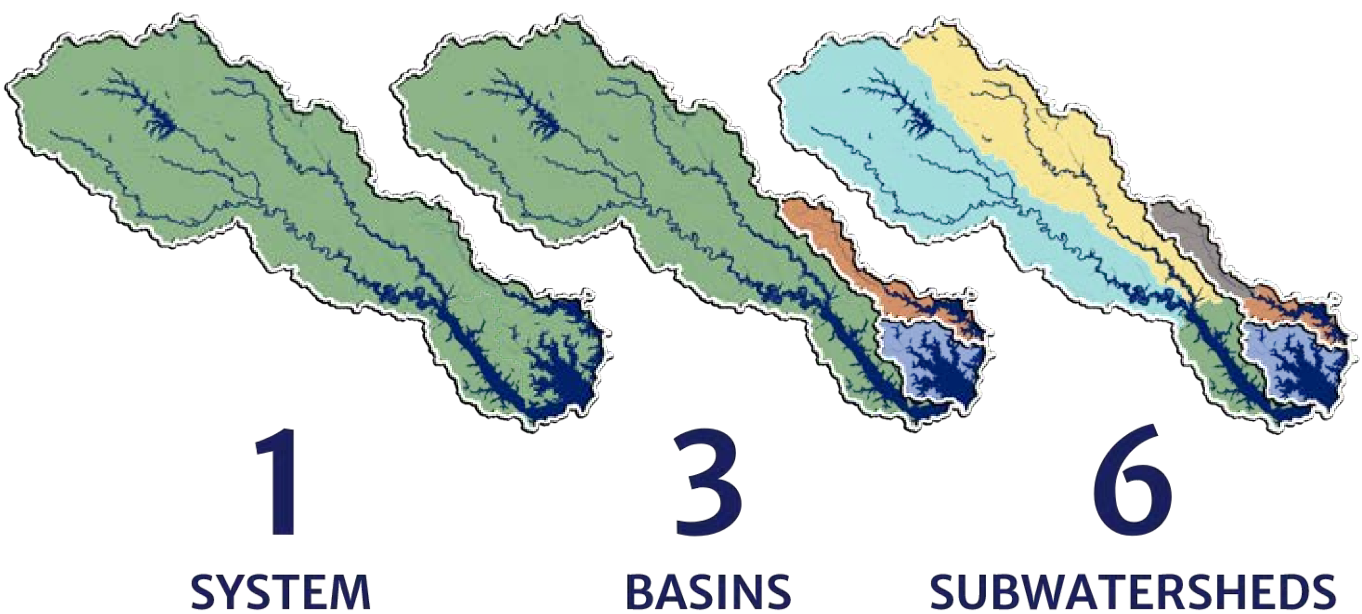
2025



Imagine ... marbles raining down from the sky. Once they hit the ground, they roll into a creek or stream, eventually making their way into a river and ultimately, the ocean. Scattered marbles can take any number of paths to get to their final destination, though some will travel toward the same streams and rivers. The boundaries that define where these marbles (or water droplets) roll, define watersheds. In a watershed, all water drains to a common water body.

EVERYONE LIVES IN A WATERSHED.

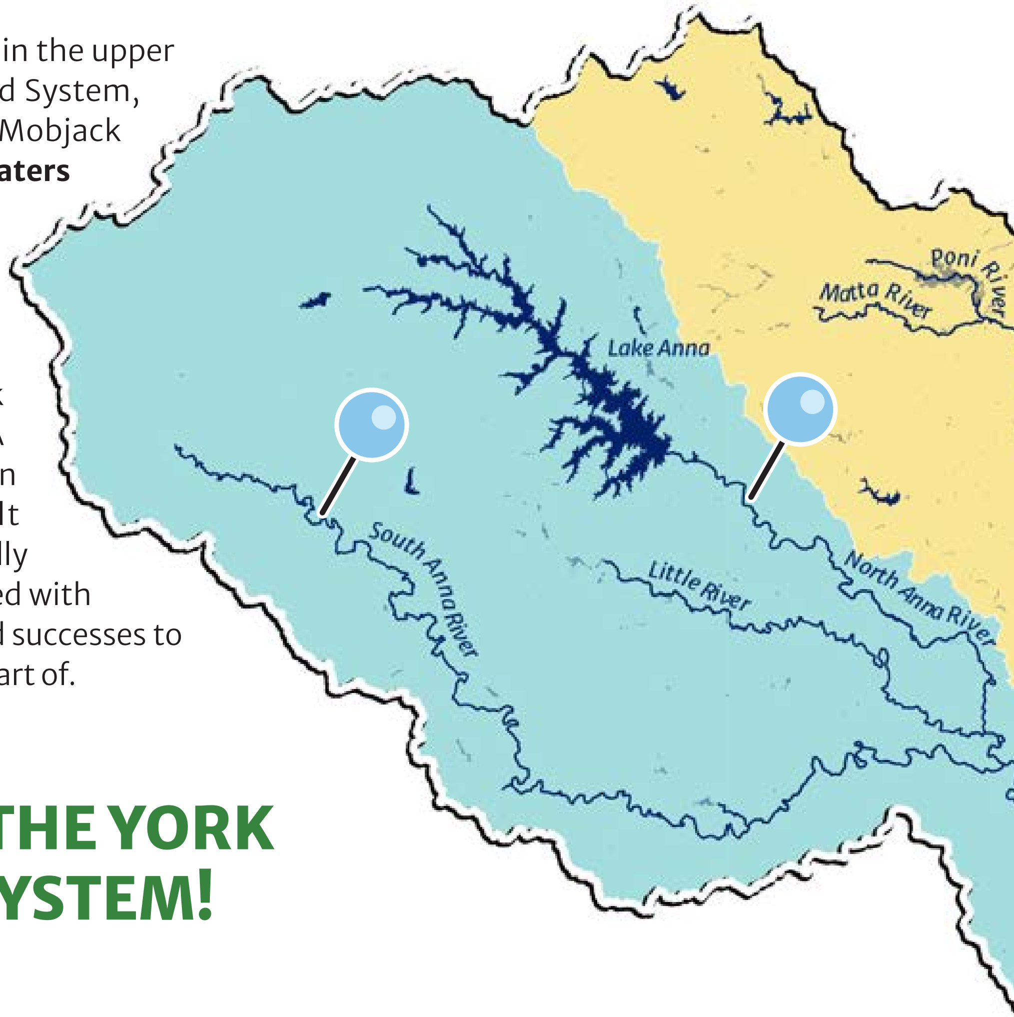
This report is dedicated to a collection of watersheds that we're calling the **York Watershed System.** Comprising this system are three main watersheds, or basins: the Mobjack Bay, Piankatank River, and York River basins. Within each distinct basin, water droplets traverse a peopled land, ultimately draining into water bodies that provide habitat for a slew of flora and fauna, sustain our local economies, and enhance our quality of life.



OUR WATERSHED SYSTEM

From the shores of Lake Anna in the upper reaches of the York Watershed System, to the aquaculture cages of Mobjack Bay in the lower, **our System waters connect communities - to each other, and to our watersheds.**

The pages that follow represent a sliver of the York Watershed System's story. A story of connections between human, natural, and built entities that have become vitally interdependent. A story imbued with both failures to learn from, and successes to build on. A story that you're a part of.



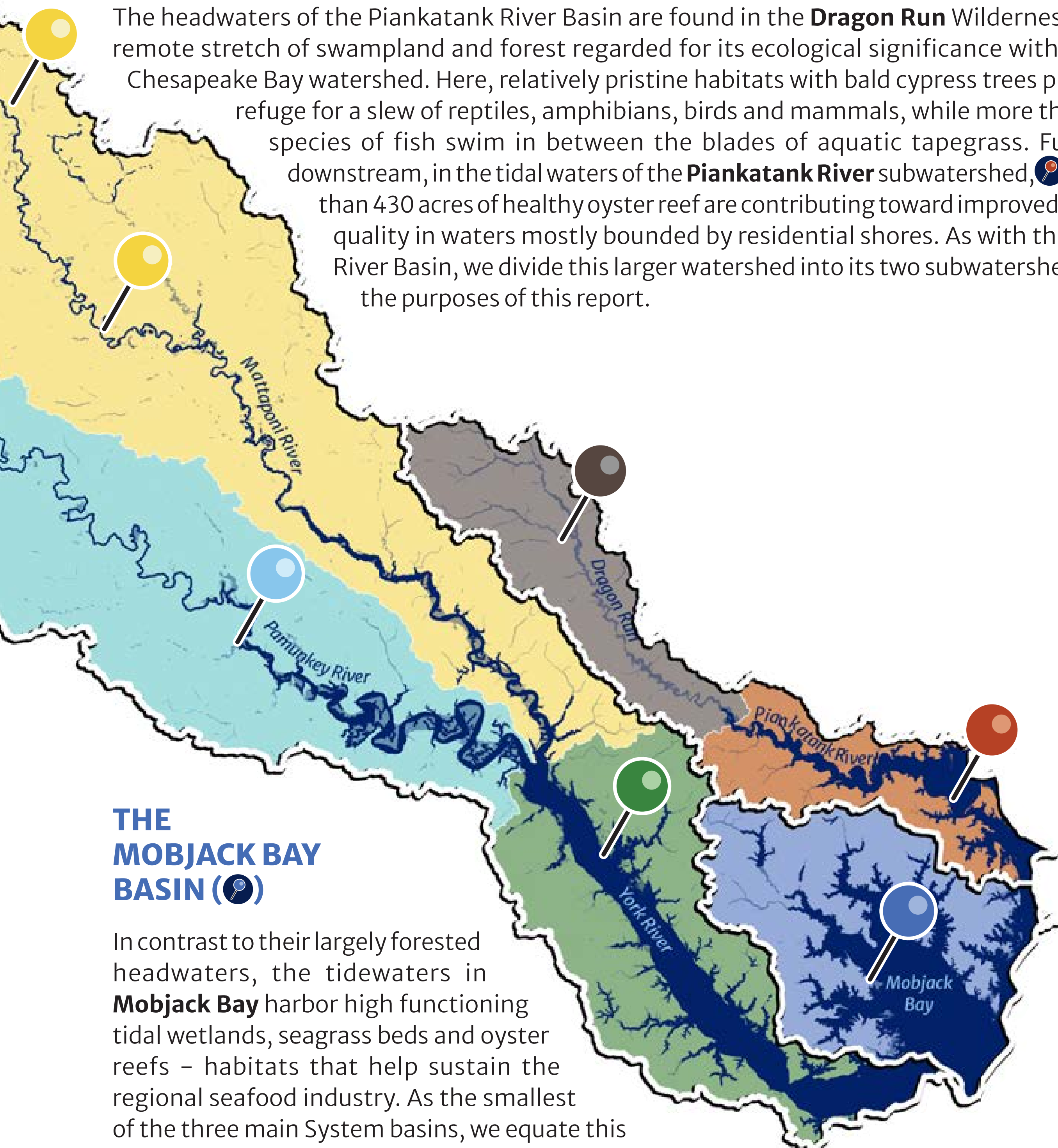
WELCOME TO THE YORK WATERSHED SYSTEM!

THE YORK RIVER BASIN (| |)

Of the three component basins, the York River Basin is the largest, most populated and most diverse with respect to habitats and land use. Water droplets within this watershed travel from Piedmont to the coast, emptying out into the Chesapeake Bay. On their journey southeast, they may move through non-tidal, freshwater creeks and streams into the North Anna or South Anna of the **Pamunkey River** subwatershed, if not the Matta, Po or Ni rivers in the **Mattaponi River** subwatershed, before reaching the tidal waters of the Pamunkey and Mattaponi rivers. Converging in West Point, these tributaries combine to feed the increasingly saline waters of the **York River**, a subwatershed of its own and the Bay's fifth largest tributary in terms of flow and watershed area. We divide the larger, York River Basin into its respective subwatersheds specific to distinct drainages for the purposes of this report.

THE PIANKATANK RIVER BASIN (|)

The headwaters of the Piankatank River Basin are found in the **Dragon Run** Wilderness, a remote stretch of swampland and forest regarded for its ecological significance within the Chesapeake Bay watershed. Here, relatively pristine habitats with bald cypress trees provide refuge for a slew of reptiles, amphibians, birds and mammals, while more than 45 species of fish swim in between the blades of aquatic tapegrass. Further downstream, in the tidal waters of the **Piankatank River** subwatershed, more than 430 acres of healthy oyster reef are contributing toward improved water quality in waters mostly bounded by residential shores. As with the York River Basin, we divide this larger watershed into its two subwatersheds for the purposes of this report.



THE MOBJACK BAY BASIN ( )

In contrast to their largely forested headwaters, the tidewaters in **Mobjack Bay** harbor high functioning tidal wetlands, seagrass beds and oyster reefs – habitats that help sustain the regional seafood industry. As the smallest of the three main System basins, we equate this basin with a subwatershed for the purposes of this report.

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STATE OF THE YORK

INTRODUCTION

PAST, PRESENT, FUTURE

Nearly 25 years have passed since the last report on the state of the York River was delivered, and at least 15 since the York River Estuary's most recent profile was published; a lot has changed since. The system's population has grown. Land has been developed. More rain is falling. Sea levels have risen. The behaviors we've long practiced on land and sea have started to impact us in meaningful ways. Climate change is now forcing us to grapple with a myriad of challenges requiring urgent solutions. ...And we're responding.

Restoration efforts are returning oysters to our shores and protecting our shorelines. In our classrooms, we're addressing environmental literacy and in our communities, we're empowering residents and visitors alike to monitor and steward our shared lands and waters. Resilience is becoming a part of our collective conscience, and we're taking proactive steps to help secure it in the face of stressors increasing in both severity and frequency.

Members of the York River and Small Coastal Basin Roundtable gather at an All-Hands meeting for an activity on watershed values and threats. *Credit: CBNERR-VA.*

On all these fronts, we're engaging as a community. The York River and Small Coastal Basin Roundtable (Roundtable) is one way in which community members have engaged to elevate and safeguard quality of life within our System. Indeed, Roundtable members are among those who have mobilized to bring you this report, aimed at addressing your most pressing questions. Dedicated to healthy and resilient watershed habitats, and communities therein, Roundtable members represent a variety of perspectives from those who live, work and play in the York Watershed System, from Piedmont to Tidewaters. Collectively, members celebrate System-wide assets and connectivity, and work toward fishable and swimmable waters for all.

Fortunately for the Roundtable, there is precedent. Since time immemorial, **indigenous peoples have inhabited the banks of the York River**. Along its shores, Pocahontas and her Powhatan peoples thrived. The weathered and historied story that follows provides no shortage of lessons learned. From the first European settlement in the Chesapeake Bay, to the end of the revolutionary war, the shores of the York River provide countless opportunities to learn from a complicated past, while the future offers continued opportunity to course correct. As a community, the Roundtable continues to evolve to meet this challenge.

Our job herein is to tell the present day story, using contemporary data to showcase **status** St, **trends** Tr and **opportunities** Op throughout the watershed system. But it's not without an acknowledgment of the past that brought us here, both good and bad, as we still have a lot to learn from each. With this in mind, we invite you to journey with us, over our land and into our waters as we describe our York Watershed System. Celebrate with us the wins we have collectively made, evolve with us to meet the challenges we collectively face, and act with us to steward our shared environment in a manner that only we all can do ***together***.

Environmental literacy in action at York River State Park. *Credit: CBNERR-VA.*

HOW TO USE THIS REPORT

We hope to take you on a tour as you read through the following pages – beginning with **our land**, moving into **our waters**, and ending on the **resources** dependent on them, something akin to the journey of a water droplet. Recognizing that these three interdependent facets of our environment are inseparably connected to each other and to us, and that between them there are no hard and fast lines, we distinguish them here to help organize the story unfolding in your backyard. Our aim: to provide you with a **timely, accessible and interactive** overview of the York Watershed System.

Re: timely, the data and studies we showcase reflect the most contemporary available, though, depending on topic, some of the stories they tell may be older than others. We've stitched together the best information on hand to relay the York Watershed System story, and while over the past 20+ years, a lot has changed, and a lot of new and updated information on the System has surfaced, it's done so at different rates for different topics. You'll see this reflected as you page through our report.

Re: accessible, given the scale and scope of our System, you'll also note that we've divided it into six **sub**watersheds (see pages iii and iv). Where data or a story pertain to a specific subwatershed, you'll see a related graphic, color-coded accordingly. This place-based emphasis will help highlight the data most meaningful to you. Within these subwatersheds, terminology is used in many ways. In recognition of these various interpretations, we define the language we use throughout this report in the Glossary for a Shared Understanding (page 95).

NAVIGATION TIP!

If content on a page relates to a specific subwatershed, you'll find the respective pin icon on the white tab in the upper out-side corners of the page.

- Dragon Run
- Mattaponi River
- Mobjack Bay
- Pamunkey River
- Piankatank River
- York River

NAVIGATION TIP!

The following icons are found throughout the report for quick reference:

- Call to Action
- Did You Know
- Case Study
- Tool Feature
- Flagged for more study and development
- Status
- Trends
- Fast Fact
- Resources
- Opportunities

*If you're looking for a specific topic, try the INDEX first

Re: interactive, while we've done our best to showcase the latest research and data, what you'll find on these pages represents the tip of the iceberg! As a **call to action**, we encourage you to interact with the links to **resources** and **tools** sprinkled throughout the report for continued exploration and study. Click on figures and maps to explore these visuals in depth and at higher resolutions. Then check out the Learn More Here section on page 94 for more on our One-Stop System Shop, a comprehensive resource and tool inventory for System-related information.

You, our reader, are someone who lives on, depends on, visits and/or celebrates the York Watershed System – but most of all, someone who can make a difference in it. How, you ask? Be on the lookout throughout the report for more **calls to action**, and check out the section dedicated to the topic on page 93. Learn where you can take action to protect and steward your watershed waters and inspire others to do the same. Go a step further and advocate on behalf of your watershed community by sharing this report with your elected officials.

NAVIGATION TIP!

Check page borders for an indication of the section you're in.

PRO TIP!

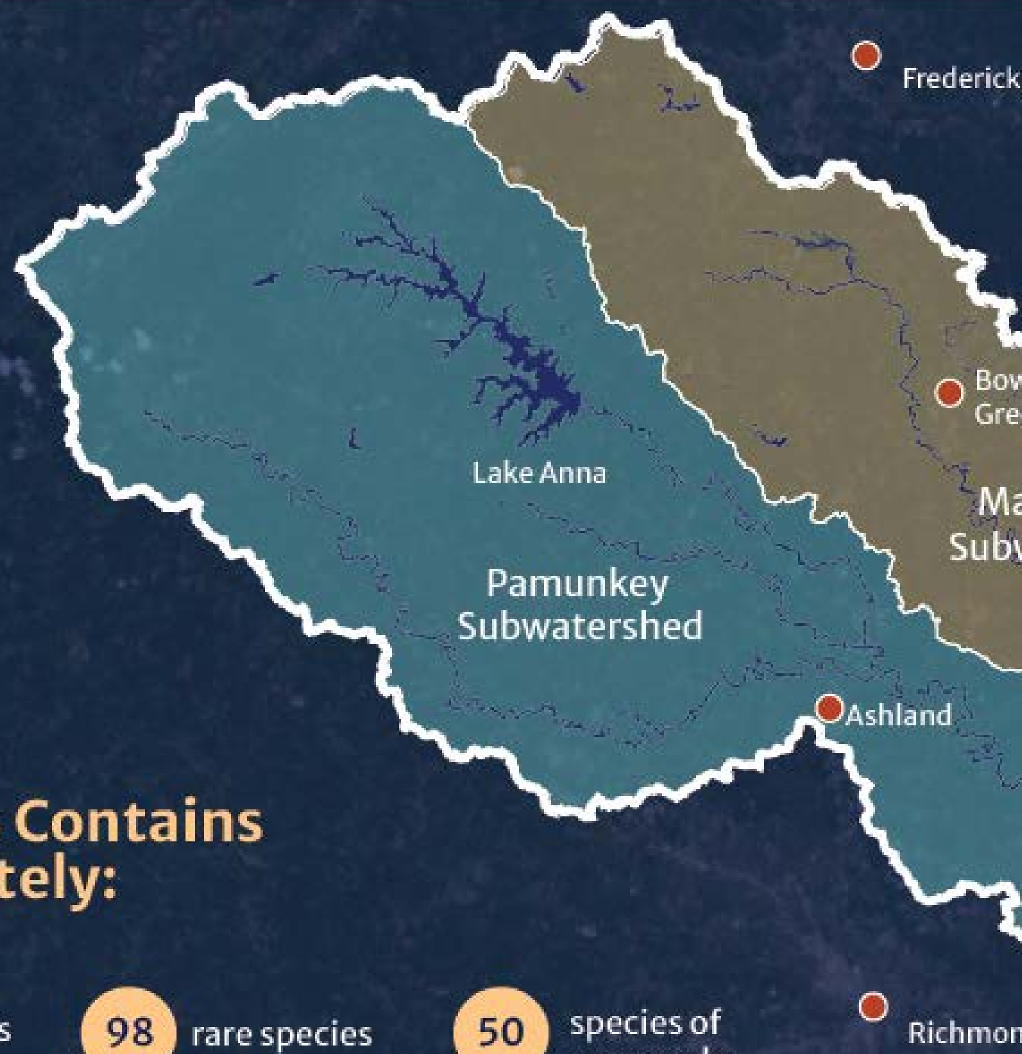
Want to zoom in on figures and tables? Click on any figure, or use the hyperlinks in its caption, to see it close up!

Whether it regards where to swim, what to eat, where to invest, what studies to pursue, or what funding to seek, we also hope you'll use this report in your decision-making. You'll note that our most pressing and lingering questions are **flagged** throughout the report to inspire and fuel new studies relevant to identified knowledge gaps. Continued study of these topics will provide the necessary context for the most informed management of our York Watershed System, and prepare us as we transition into the System's next chapter.

Art in the Park at Machicomoco State Park. *Credit: S. Nuss.*

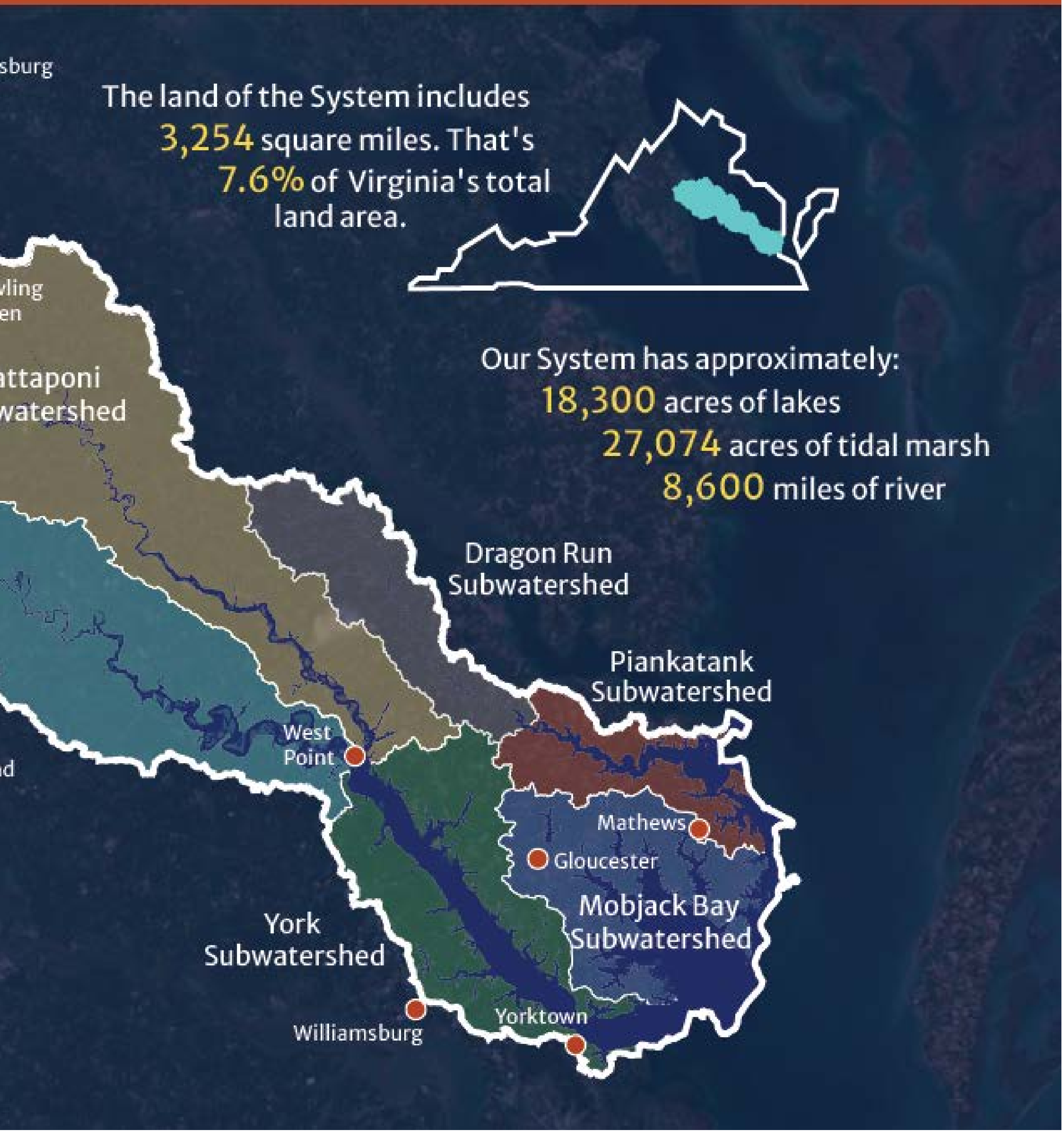
OUR SYSTEM, AN OVERVIEW

The York Watershed System stretches more than 220 miles from its headwaters in the Piedmont to the salt marshes of Mobjack Bay, encompassing a total of six subwatersheds.



Our System Contains Approximately:

- **350** protected areas
- **98** rare species
- **50** species of mammals
- **68** public access sites
- **200** species of fish
- **36** species of reptiles
- **54** significant natural communities
- **190** species of birds
- **26** species of amphibians

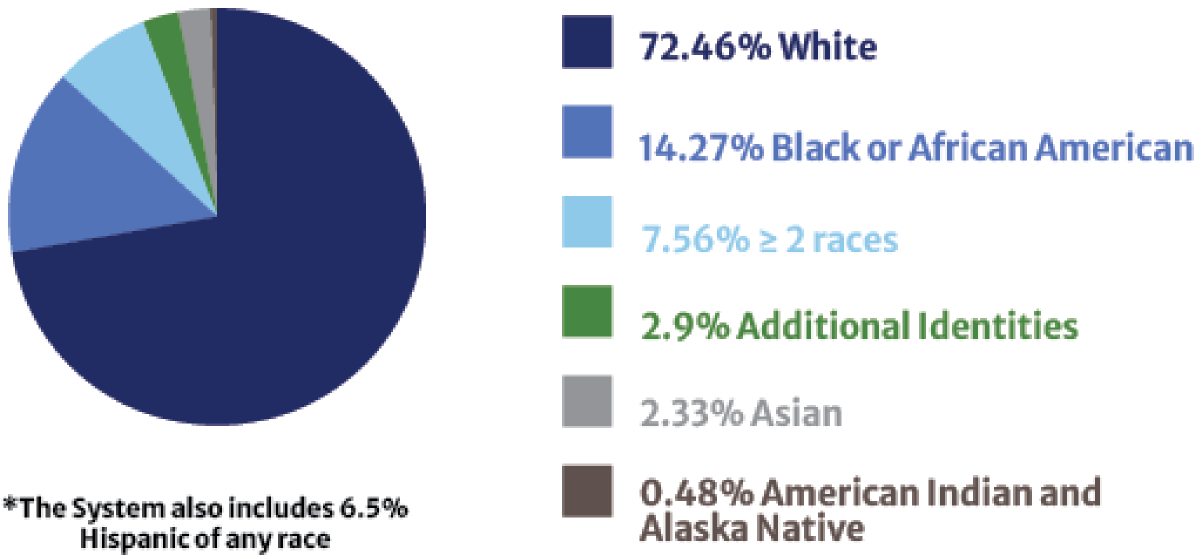


Credit: Green Fin Studio.

OUR PEOPLE, AN OVERVIEW

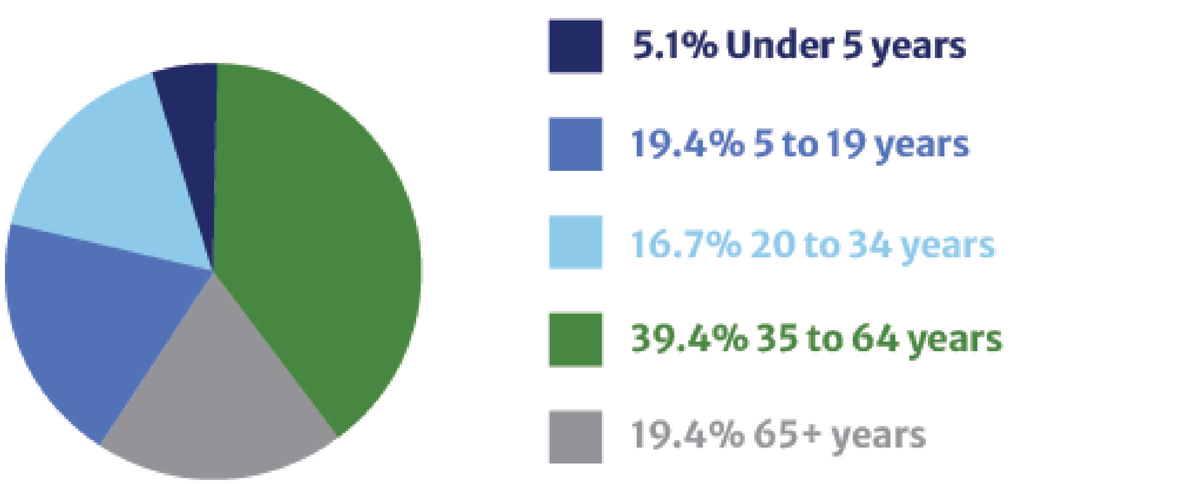
As of 2024, more than 630,000 people live in the York Watershed System.

Race Demographics within the York Watershed System*



*The System also includes 6.5% Hispanic of any race

Age Demographics within the York Watershed System



11

Our System includes 11 Indigenous peoples nations.

31%

31% of households have at least one person under the age of 18.

10.7%

Our System experienced a 10.7% increase in population between 2010 and 2020 at an annual growth rate of 1.07%.

$85,139

Median household income is $85,139.

$34 BILLION

Our counties contributed more than $34 billion gross domestic product (GDP) in 2022.

7.6%

7.6% of households had 12-month incomes below the poverty level in 2021.

Within Our System, you will find:

- **17** Counties and one indepedendent city
- **8** Soil and Water Conservation Districts (SWCDs)
- **6** Planning District Commissions (PDCs)
- **12** VA House seats
- **7** VA Senate seats
- **3** Congressional Districts

Credit: Green Fin Studio.

State of the York

Credit: Green Fin Studio.

Delighting in regional waters. *Credit: S. Lerberg.*

OUR CHANGING LANDSCAPE

A flooded roadway in the Middle Peninsula. *Credit: Consociate Media.*

OUR CHANGING LANDSCAPE

The York Watershed System has long maintained a predominantly natural landscape, namely characterized by forest with some agriculture. Rural communities, found throughout the System, have historically represented the dominant residential character, with the exception of one major population center in Williamsburg. Beginning in 2000, the System began experiencing increases in population that rivaled other Chesapeake Bay watersheds.

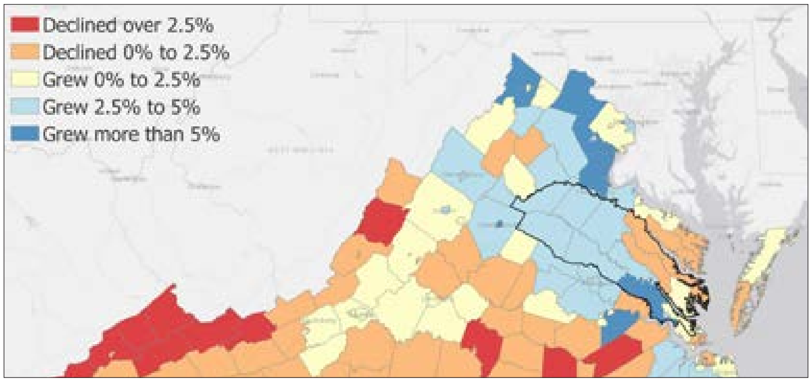


Figure 1. Population Change during the 2010s (3-yr average). ***Source:*** *UVA Cooper Center.*

In the 2010s, System counties experienced varied population changes, with slow growth throughout the majority of the System and declines experienced in Middle Peninsula counties ***(Figure 1)***.

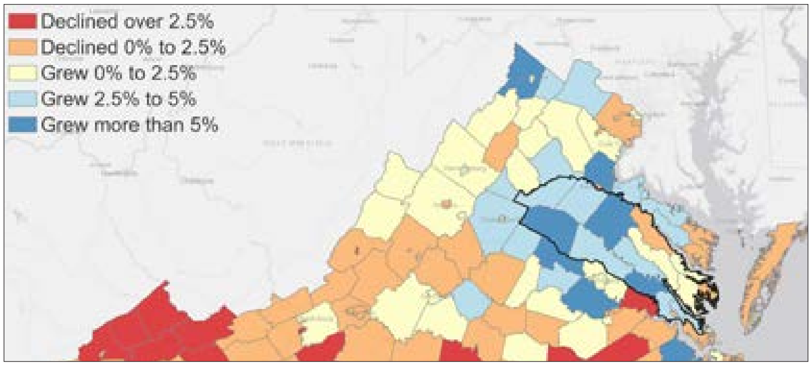


Figure 2. Population Change 2020 to 2023. ***Source:*** *UVA Cooper Center.*

Post-COVID, these population trends shifted, and System counties became among the fastest growing in the state ***(Figure 2)***.

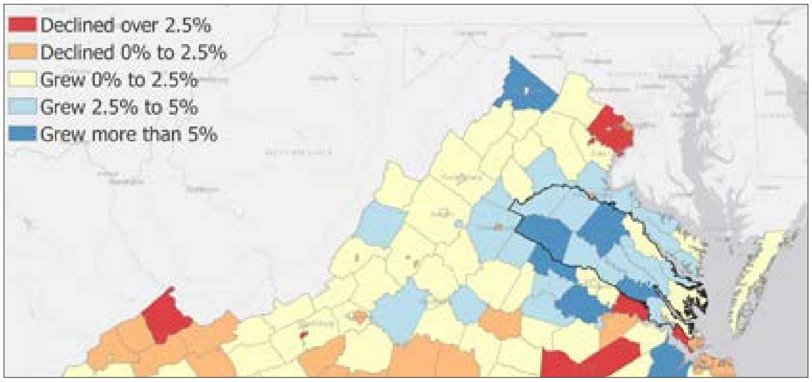


Figure 3. Change in Population from Migration 2020 to 2023. ***Source:*** *UVA Cooper Center.*

Migration, namely stemming from adults under age 45 departing nearby metropolitan centers, has contributed to these recent increases in population change ***(Figure 3)***. During the 2010s, this age group declined in the System. The current trend however, is expected to continue into the foreseeable future as prospective residents look to leverage the System's natural assets.

Increases in population over time have necessitated accompanying infrastructure, which we equate with the term development. The construction of a built environment, including houses,commercial and municipal buildings, in addition to the paving of roads and parking lots, are all facets of this development.

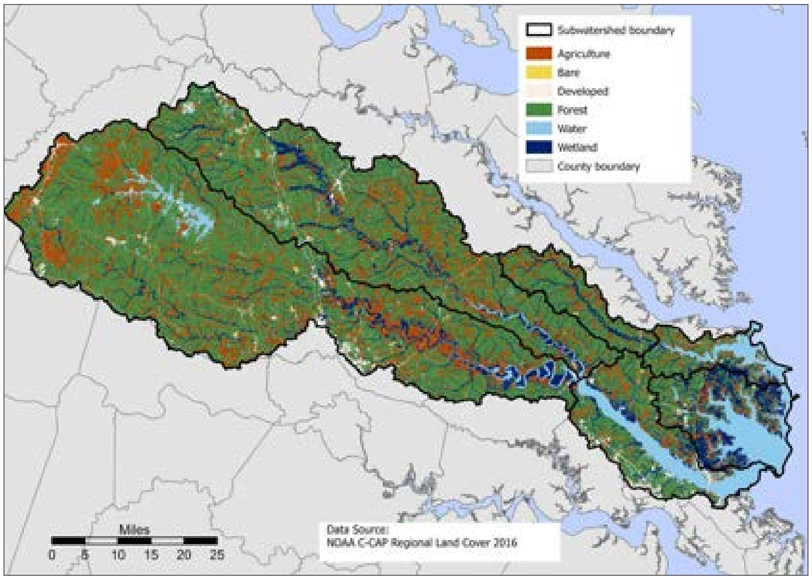


Figure 4. Land cover within the York Watershed System in 2016, by subwatershed and use sector. ***Source:*** *NOAA C-CAP*.

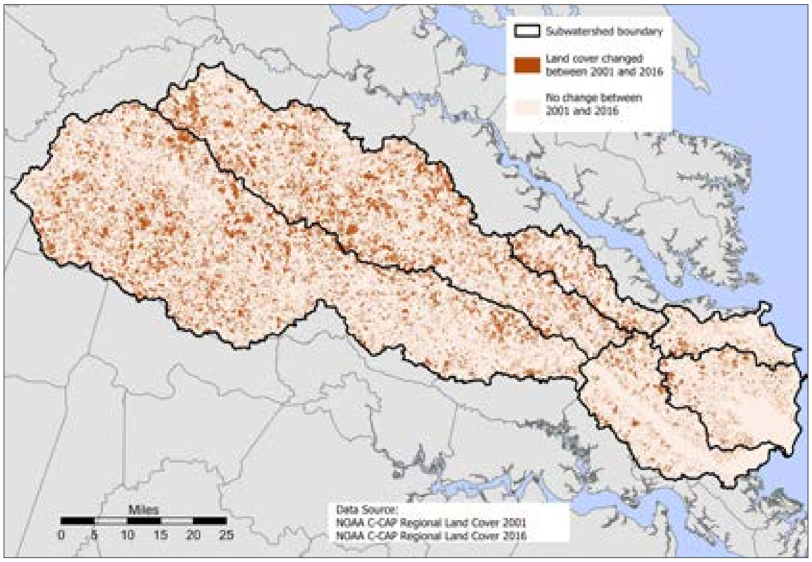


Figure 5. Land cover change by subwatershed between 2001 and 2016. *Source: NOAA C-CAP*

Between 2000 and 2020, the York Watershed System grew by more than 170,000 people and 76,000 housing units (*Source:* ***U.S. Census Bureau Decennial Census***).

The most recent and complete analysis of coastal land cover change in the York Watershed System landscape, created in 2016, indicates that the System remains largely natural ***(Figure 4)***. Notably, this map, and the data associated with it (***Table 1***) predate the System's most recent population increases, detailed on page 3.

When compared to the iteration of this map from 2001, land cover change is detected throughout the System ***(Figure 5)***. Where evidence of this change is found, exchanges between forest and agriculture are detected, though developed land cover is attributed with the largest increases.

While development has brought us new business and job opportunities as well as new housing and community, we've traded natural resources (like forests and wetlands) in the process, at times impacting water quality and living resources along the way. Restoration efforts are helping to mitigate the loss of these natural assets though their implementation has not kept pace with our natural asset loss. In the coming pages, we'll describe some of the changes to our assets. Their associated impacts are detailed throughout the remainder of this report.

St
Tr

From 2001 to 2016, the York River subwatershed experienced the largest increase in developed land and simultaneously, the largest loss of forest. The Pamunkey River subwatershed experienced the largest increase in bare land, tying with the Dragon Run subwatershed for the greatest loss in wetlands. Meanwhile, the Dragon Run subwatershed experienced the largest increase in agricultural lands. Minor increases in York River subwatershed wetlands may be associated with sea level rise.

		Subwatershed						% of System's total land cover area assesed (2016)
		DRAGON RUN	MATTAPONI RIVER	MOBJACK BAY	PAMUNKEY RIVER	PIANKATANK RIVER	YORK RIVER	
Land Cover Grouping	developed	5.7	14.4	11.4	13.6	8.0	15.1	4.33
	agriculture	6.6	2.6	0.8	3.8	3.2	1.2	20.10
	forest	1.7	1.1	0.4	1.9	1.6	3.6	62.53
	wetland	2.5	2.4	1.4	2.5	1.4	0.7	12.75
	bare	15.5	35.5	23.6	35.7	33.6	32.9	0.28

Table 1. Percent change in land cover from 2001 to 2016; green indicates an increase in respective land cover from 2001 to 2016 while red indicates a decrease. Land covers as percentages of total System area assessed in 2016 are detailed in the last column. *Data source: NOAA C-CAP.*

Relative to its neighboring, coastal watersheds, the York Watershed System is not the most developed on the whole (***Figure 6a***), though in its upper reaches, it contains a greater percentage of developed lands than its neighbors (***Figure 6b***). Forest dominates land cover throughout all three of these adjacent regions, though percent cover is greatest in the James River watershed. Non-forested natural areas, inclusive of wetlands, comprise the smallest proportions of land cover in all three geographies. Among the three watershed regions however, these natural areas exhibit the highest percent coverage within the York Watershed System.

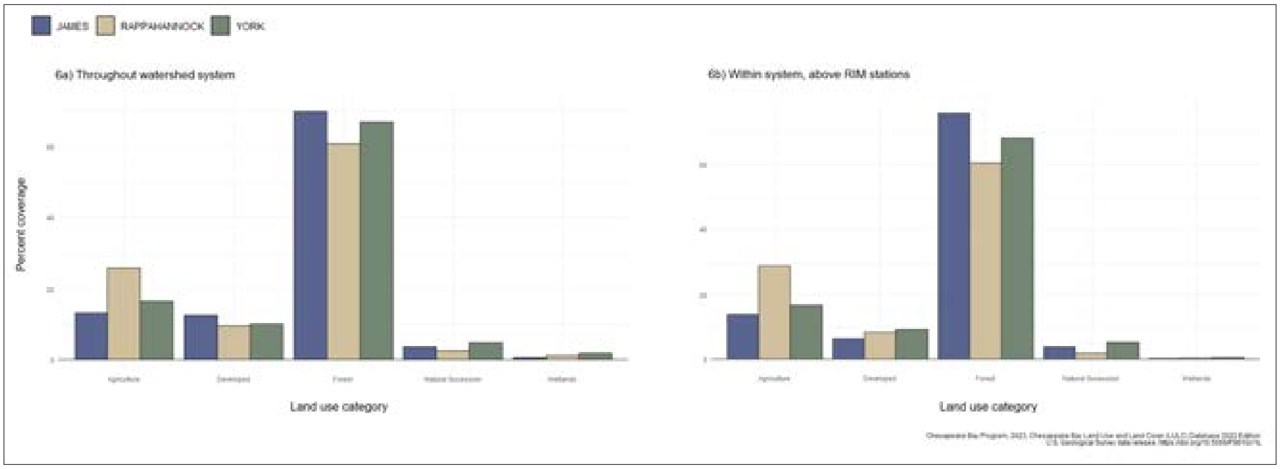


Figure 6. Percent of land use coverage in Virginia's coastal watershed systems, 2018, a) throughout watershed system; b) within system, above RIM (River Input Monitoring) stations. *Data source: Chesapeake Bay Land Use and Land Cover Database, 2022 Edition. Credit: E. Reilly.*

Land cover in the York Watershed System is **75% natural**.

A closer look at existing natural areas within the System provides us an indication of potential conservation opportunities. **Table 2** reflects the current acreage of select natural areas, or habitat types, by subwatershed as a percent of the System's total. While the Mobjack Bay subwatershed maintains the greatest percentage of the System's natural area acres, these acres are among the least conserved. Private ownership can complement conservation, but not an insurmountable one.

Conservation easements are tools private homeowners have at their disposal to help secure a property's conservation values for future generations. These voluntary, though legally binding agreements limit land use while allowing for landowners to retain their private property rights. Green Springs National Historic Landmark District is a 14,000 acre area within the York Watershed System with properties under conservation easements managed in part by the National Park Service.

		SUBWATERSHED					
		DRAGON RUN	MATTAPONI RIVER	MOBJACK BAY	PAMUNKEY RIVER	PIANKATANK RIVER	YORK RIVER
Natural feature	DCR Conservation Lands	6.97	**59.71**	1.85	7.42	0.21	23.84
	Dune	0.00	0.00	**88.08**	0.00	11.92	0.00
	Emergent Wetland	0.34	6.57	29.49	**50.17**	3.81	9.63
	Forested Wetland	0.00	10.15	**44.99**	26.65	7.05	11.16
	Scrub-Shrub Wetland	2.50	6.02	**55.51**	15.65	5.49	14.83
	Tidal Marsh	5.41	16.55	22.85	24.93	4.34	**25.92**
	Wooded	0.01	7.28	**52.09**	7.16	13.65	19.82

Table 2. Percent of total natural land area type within the York Watershed System, by subwatershed. Highlighted boxes indicate the subwatershed containing the highest percentage of a given natural area. Assessed using data from the Shoreline and Tidal Marsh Inventory over available years.

There are more than **430 conservation easements** within the York Watershed System.

Consider a conservation easement! Check out **page 79** for info on the land conservancies that can help guide you through one.

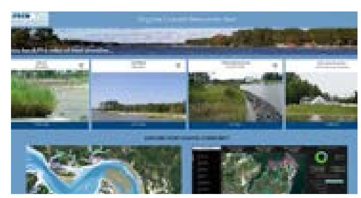
St

One of the System's most iconic, if not important, natural areas, or habitat types, is the marsh. Marshes are a type of wetland, characterized by water cover and distinguished by their plant cover (which tends towards plants vs. shrubs). Marshes reduce wave energy and shoreline erosion, improve water quality by trapping sediments and nutrients, and are home to a variety of fish and wildlife that inspire recreation and tourism.

		Tidal Marshes		Non-Tidal Marshes	
Subwatershed	**Total area (acres)**	**Acres**	**Percent coverage within System**	**Acres**	**Percent coverage within System**
Dragon Run	89,943.9	78.0	**0.29**	10,248.6	**5.26**
Mattaponi River	583,146.5	4,782.8	**17.67**	59,566.7	**30.54**
Mobjack Bay	155,347.1	6,455.0	**23.84**	24,571.4	**12.60**
Piankatank River	75,902.4	1,241.1	**4.58**	5,863.9	**3.01**
Pamunkey River	942,544.6	7,177.2	**26.51**	85,574.6	**43.88**
York River	186,748.6	7,340.3	**27.11**	9,190.2	**4.71**
TOTALS	**2,033,633.1**	**27,074.3**	**1.33**	**195,015.4**	**9.59**

Table 3. Extent of marshes, tidal and non-tidal, within the York Watershed System as of 2022. Depicted in acres respective to each subwatershed, alongside a percentage representing prevalence relative to System's total respective marsh acreage. *Data source: Center for Coastal Resources Management (CCRM), 2019.* **Virginia Shoreline and Tidal Marsh Inventory.**

The information in Table 3 can be obtained and visualized using the **Virginia Coastal Resources Tool**. Notably, a new iteration of the tidal marsh inventory began development in October 2023.



Aerial image of Pamunkey River subwatershed marsh. *Credit: CBNERR-VA.*

Between the early 1970s and 2009, the York Watershed System experienced a loss of approximately 540 acres or ~2.7% of tidal marsh area, an area equivalent in size to approximately 409 football fields.

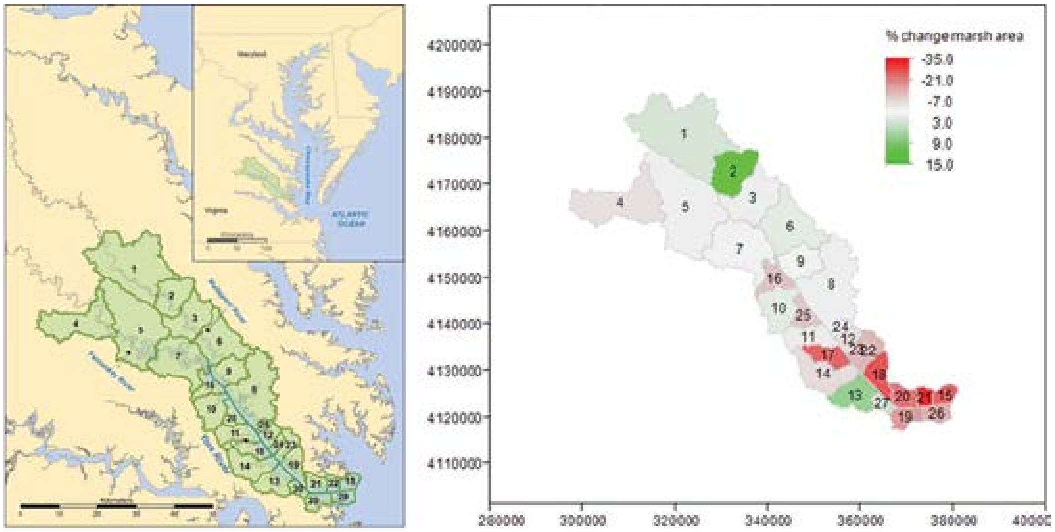


Figure 7. Percent change in tidal marsh area along the York Watershed System with map for reference map. *Credit:* ***Mitchell et al. 2017***.

Tidal marsh change varied tremendously within the System's subwatersheds during this period (***Figure 7***), with an overall average loss of 8% marsh area per subwatershed. Up to 33% of this loss was likely due to erosion, namely in high energy areas of the System characterized by strong waves, fast water currents, and/or powerful winds. The lack of landward migration capacity for marshes contributed to loss as well. Notably, development was the most important predictor of marsh loss.

Both tidal and freshwater marshes naturally keep pace with changing water and sediment levels, spreading to accommodate the plants they harbor as waters rise or the sediments they grow from deepen. This migration process naturally occurs over decades, though rising waters are presently forcing faster adaptations. During the same timeframe of the marsh loss detailed above, sea levels rose approximately 8 inches in the York Watershed System. This sea level rise may have contributed to marsh loss in areas where marshes were unable to migrate landward. Steep slopes, or barriers such as shoreline armoring or impervious surfaces, impede the natural tendency and capacity of a marsh to migrate.

Inundation of a tidal marsh in Mobjack Bay. *Credit: Aileen Devlin | Virginia Sea Grant.*

A few subwatersheds, particularly the upper/riverine areas, increased in marsh area during this same period; up to 11% of this increase was likely due to expanded inundation, or sustained flooding, which fostered marsh migration.

St

Maintaining space for marshes to migrate inland is crucial to the preservation of this important habitat as sea levels continue to rise.

Figure 8 depicts our current tidal marshes, and the potential areas that they could migrate to with increasing sea levels. The catch? Watershed residents have homes, farmlands and businesses, or would like to build homes, farmlands and businesses, in many of the same areas that marshes want to move toward. Do we prioritize development or marsh in these known marsh migration pathways? Answering this delicate question requires trade-offs in either direction. Weighing the many competing factors is a task decision-makers are continually addressing.

Evidence of a migrating marsh in the Mobjack Bay subwatershed. Credit: Aileen Devlin | Virginia Sea Grant.

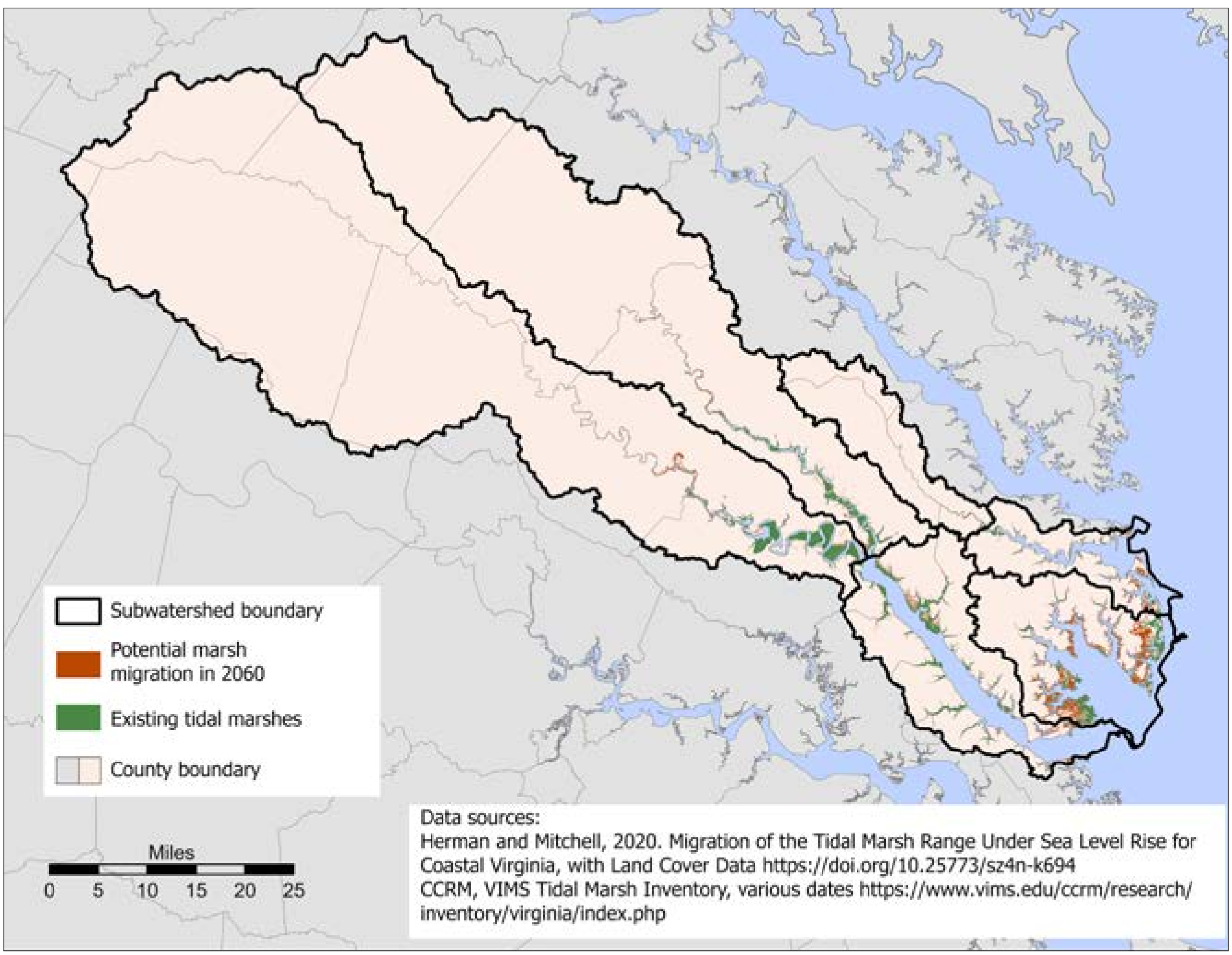
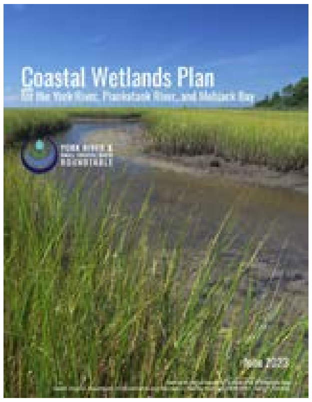


Figure 8. Current tidal marsh extent and potential migration within the York Watershed System, by subwatershed. *Source: Herman and Mitchell 2020*.

In the Commonwealth, there exists a compromise that helps maintain tidal marsh and other wetland habitat, while allowing for development to proceed. That compromise takes the form of a "no net loss" policy for wetlands, meaning that for any loss of existing wetland acreage, there must be compensatory mitigation with respect to acreage and function. Notably, this loss need not stem from development, and can be a factor of environmental impacts, like sea level rise. Likewise, gains through mitigation need not be human-made, and can also occur through natural processes. As a type of wetland, tidal marshes are subject to this "no net loss" policy, though the efficacy of the policy remains unclear, particularly in the face of future environmental stressors.

A System-wide analysis is needed exploring the changes in wetland coverage and habitat function within the System since 2007, when the statutory authority instituting a "no net loss" policy took effect. Such a study would confirm that System wetlands, inclusive of tidal marshes, have neither a) experienced any net loss in coverage, nor b) diminished in provision of their habitat function since the policy's inception. Findings to the contrary can help redirect related efforts. Moreover, the origins respective to each loss or gain (be they environmental or resulting from human action), assessed in concert with planned and projected development, as well as anticipated sea level rise and marsh migration corridors, can address future zoning, conservation and restoration efforts in a comprehensive fashion.



The York River Roundtable's Coastal Wetlands Plan recommends conservation of tidal wetlands migration corridors.

Surveying marsh extent in the Pamunkey River subwatershed. *Credit: CBNERR-VA.*

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Sea level rise, one symptom of climate change and a contributing factor in marsh migration, results from oceanic waters warming and expanding in combination with glacier melt. In coastal Virginia, sea level rise is exacerbated by land subsidence, or sinking. While imperceptible to watershed residents, our land is subsiding at an average rate of approximately 1/10 of an inch/yr (3 mm/yr to be exact) due to a combination of tectonic movement and the depletion of our aquifer (for details read on through the resources linked to the right).

The U.S. Geologic Survey has studied subsidence in coastal Virginia extensively.

Visit these websites for more info from multiple angles:

- **Land Motion and Subsidence on the Virginia Coastal Plain** – a geonarrative
- **Land Subsidence on the Virginia Coastal Plain** – overview and hub
- **Land subsidence and relative sea-level rise in the southern Chesapeake Bay region** – a report

Between this sinking and the sea levels rising, Tidewater residents are experiencing the highest relative sea level rise (SLR rates) on the East Coast.

Sea level rise can be modeled using a variety of future scenarios characterized by varying increases in greenhouse gas emissions, ocean and atmospheric warming, and land subsidence. ***Figure 9*** illustrates sea level rise in future scenarios, intermediate and intermediate high, the latter reflecting greater increases in climatic changes. These maps were developed using NOAA's Sea Level Rise Scenarios (2017) along with elevation models generated from lidar data and corrected using tide gauge data. Each scenario is depicted at two target years, 2050 and 2070. Comparing these results helps us understand future inundation, or flooding, potential.

Flooded marsh at high tide. *Credit: CBNERR-VA.*

The Center for Coastal Resources Management at the Virginia Institute of Marine Science maintains Sea Level Rise Report Cards for 32 U.S. coastal localities. **Compare report card values here.**

Survey of a flooded marsh at high tide. *Credit: CBNERR-VA*

The areas these maps depict translate to the acres detailed in **Table 4**. Based on these scenarios, the York Watershed System may collectively experience a 59 to 72 percent increase in flooded areas by 2050; by 2070, this range increases to between 96 and 124 percent. Of the six subwatersheds in the System, Mobjack Bay is projected to experience the greatest increases in flooded area of time, under either scenario.

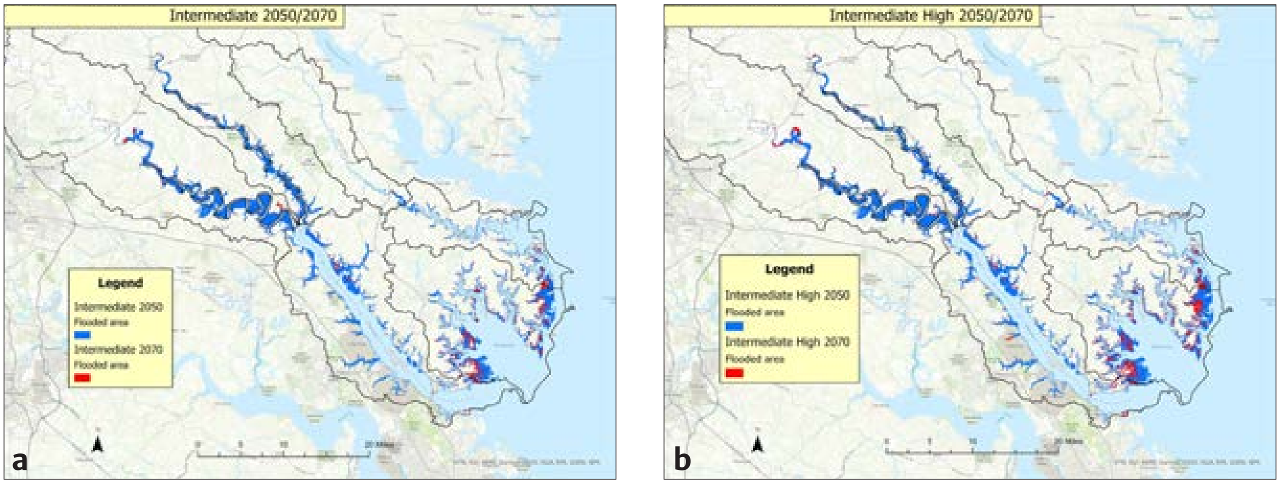

Figure 9 a and b. Projected 2050 and 2070 flooded areas in the York Watershed System by subwatershed using a) intermediate and b) intermediate high scenarios, respectively.

			Future Scenario			
Subwatershed	**Total acres**	**Current (2020) flooded area (acres)**	**Intermediate 2050 (acres)**	**Intermediate High 2050 (acres)**	**Intermediate 2070 (acres)**	**Intermediate High 2070 (acres)**
Dragon Run	89,944	180.1	110.33%	122.77%	144.48%	173.68%
Mattaponi	583,147	4948.9	34.44%	37.79%	45.20%	50.89%
Mobjack Bay	155,347	2658.2	**205.52%**	**271.00%**	**403.21%**	**548.11%**
Pamunkey	942,546	10516.2	17.61%	21.19%	24.81%	30.78%
Piankatank	75,902	746.4	128.80%	165.51%	252.68%	341.61%
York	186,749	4699.4	82.57%	93.29%	111.65%	133.15%
Total (acres)	**2,033,635**	**23749.2**	**59.20%**	**72.19%**	**96.67%**	**123.99%**

Table 4**.** Projected increases of flooded acres over current (2020) projections of flooded acreage, respective to 2050 and 2070 intermediate and intermediate high scenarios. Shading indicates subwatershed with highest increases under given scenario. *Data source: Watershed Boundary Dataset downloaded from the* USDA Geospatial Data Gateway.

How many acres of wetland are reflected in these flooding projections? Identifying this affected area can help inform zoning, conservation and restoration efforts. More on **page 7**.

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There are several types of flooding in our region, and sea level rise contributes to a few. For instance, tides and storm winds contribute, respectively, to high tide flooding (aka nuisance flooding, or sunny day flooding) and storm surge, each growing increasingly more severe as sea levels rise, and in the case of storm surge, more frequent.

These events, alongside simultaneous groundwater rising (another result of sea level rise), contribute year-round toward the destruction and devaluation of property, including in agricultural fields through saltwater intrusion, and along shorelines through erosion. Moreover, they can jeopardize public safety and health by diminishing access to roads and emergency services, and by compromising septic tank integrity (see page 18). Accordingly, our safety and health are increasingly at risk.

Current estimates indicate that U.S. coastlines experience nearly twice as much high tide flooding as they did in 2000, and that by 2050, most coastal communities will experience between 45 and 70 days of high tide flooding a year (2022 State of U.S. High Tide Flooding and Annual Outlook). Adding to this frequency, is an increasing severity with anticipated sea level rise that will impact safety in travel and transportation. Sea level in the Middle Peninsula is estimated to increase by 2.2 ft (0.68m) in 2050, and by 2100, to 6.6 ft (2m) (using the NOAA 2017 Intermediate-High scenario). These increases are expected to render more than 10 miles of regional roads inaccessible by 2050, and slightly more than 480 miles of roads inaccessible by 2100.

High tide flooding in York Watershed System Tidewaters. *Credit: Consociate Media.*

The **Coastal Virginia Road Accessibility and Flooding tool** can be used to help visualize the extent of impassable roads under different sea level rise scenarios. Vulnerable infrastructure and communities can be mapped alongside road status. Visualizations of projected flooding durations are also available.

To find out more information on flooding in coastal Virginia, visit **AdaptVA.com**. In the tool section, you'll find an **interactive map** that will allow you to visualize sea level rise, flooding and storm surge in the region and your neighborhood.

Storm surge batters shorelines in York Watershed System Tidewaters. *Credit: Consociate Media.*

Shoreline erosion is particularly problematic within the York Watershed System. Between 1937 and 2009, the System experienced erosion along 95.4% of its shorelines, while less than 4% of its shorelines saw accretion, or addition (***Table 5***). Of the six subwatersheds, the Piankatank River experienced the most relative accretion, likely from more available sources of sediment.

?! The Virginia Shoreline Erosion Advisory Service Assists private landowners and localities in Virginia with erosion problems through activities including, but not limited to, site investigations and construction inspections.

	Affected shoreline length (in miles) as of 2009			Affected shoreline as a percent of total, relative to 1937		
Subwatershed	**erosion**	**accretion**	**no change**	**erosion**	**accretion**	**no change**
Dragon Run	26.0	1.1		95.85	4.15	
Mattaponi River	181.7	0.1		**99.97**	0.03	
Mobjack Bay	483.4	**38.0**	**10.1**	90.95	7.15	**1.90**
Pamunkey River	**544.4**	0.2		99.96	0.04	
Piankatank River	188.6	22.8	2.6	88.13	**10.68**	1.20
York River	516.2	18.1	0.9	96.46	3.37	0.17
Totals	**1940.3**	**80.3**	**13.5**	**95.39**	**3.95**	**0.67**

Table 5. Shoreline change as a factor of erosion, accretion or the absence of change, in York Watershed System subwatersheds between 1937 and 2009. Highlighted boxes indicate subwatershed demonstrating greatest values. *Data source: CCRM (Center for Coastal Resources Management). 2022. Virginia Tidal Shoreline Erosion Rates. William & Mary. Virginia Institute of Marine Science, Gloucester Point, Virginia.*

Exacerbating sea level rise in the Tidewaters, and contributing to flooding events throughout the York Watershed System, is precipitation. At the same time that water is rising landward from the sea, it's also raining down on the land. In fact, more water is presently raining on our System than it has since the early 1900's.

The increase in precipitation illustrated in ***Figure 10*** can be described by changes in Intensity (how hard it rains), Frequency (how often it rains), and Duration (how long it rains for). Collectively and individually, these changes have impacts that ripple through multiple sectors and facets of our lives, including dam and river safety, septic systems and wastewater treatment, nutrient and sediment transport, and even design specifications for infrastructure like roads, culverts, and gutters.

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Pluvial flooding is defined by excess rain, whereas fluvial flooding occurs as rain exceeds the natural and/or built capacity of a water body, causing them to overflow.

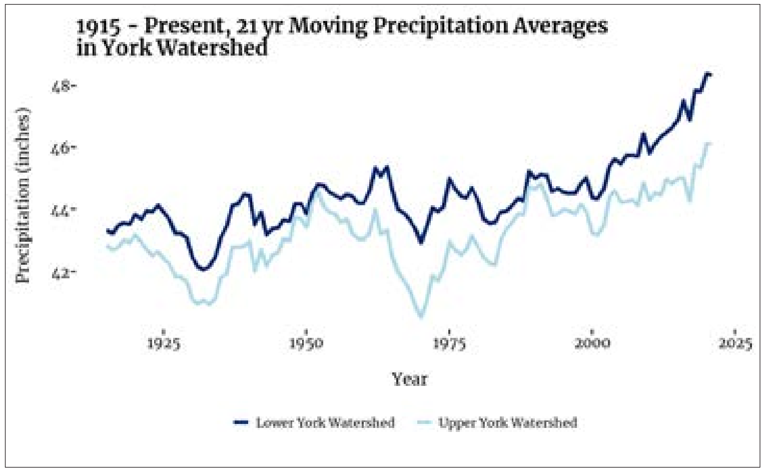

Figure 10. 1915 to present, 21 year Moving Precipitation Averages in the York Watershed System with respect to geography. Upper and lower System regions correspond with the climatic divisions illustrated in *Figure 11. Data source:* National Centers for Environmental Information.

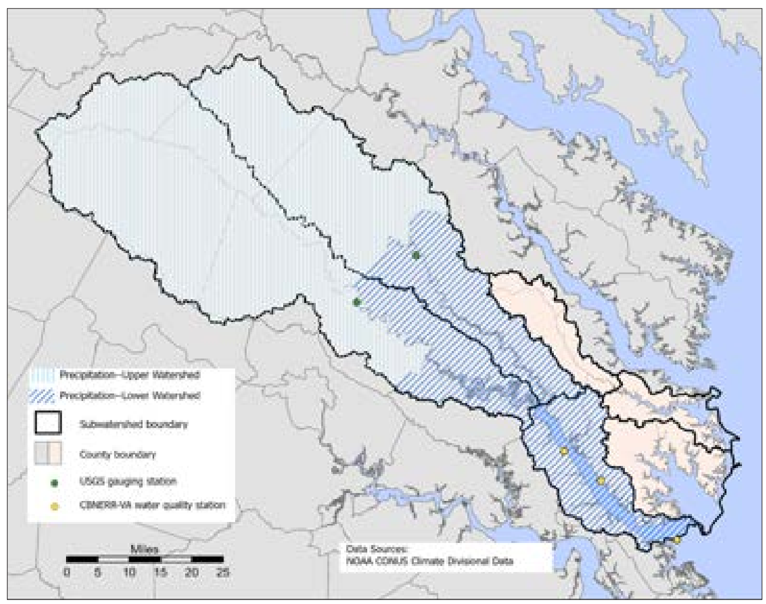

Figure 11. Contiguous United States (CONUS) Climate Divisions and water monitoring stations within the York Watershed System. Water monitoring stations help measure quantity and quality as water makes its way from the Piedmont to the Tidewaters through streams and rivers. *Credit Julie Herman. Data Source:* NOAA CONUS Climate Divisional Data.

The ability of existing roads to handle these new precipitation conditions without retrofits or replacements is limited (see page 13 for an indication of the impact). However, new construction can be adaptive. In 2020, recognizing the trends in increasing precipitation, the Virginia Department of Transportation recommended changes to design guidelines for bridges to accommodate a 20% increase in rainfall intensity and a 25% increase in discharge. VDOT followed on this recommendation with the release of a resilience plan in 2022 primarily focused on the impact of flooding to infrastructure. The plan provides a framework for the identification of vulnerable infrastructure, studies on cost effectiveness, and updated design criteria.

Flooding along the Mattaponi River. *Credit: A. Mitchell.*

A stormwater treatment system discourages dumping. *Credit: CBNERR-VA.*

Likewise, legislation passed in 2022 requires the Department of Conservation and Recreation to write a Virginia Flood Protection Master Plan using a watershed based approach by December of 2026. The goal of the plan is to provide an "actionable plan for state government to use in crafting policies and programs to mitigate the impacts of flooding on people, the economy, and the environment." This work is ongoing and includes updating rainfall projections.

Flooding events, precipitation and sea level rise all reflect changes in **water quantity**, though each in turn, also impacts **water quality**. Specifically, these events are opportunities for the transfer of sediment, nutrients and pollutants (biological and chemical, and including trash) from the land into our waterways.

Homeowners looking for insight on how to combat stormwater can find a **guideline on best practices here**, thanks to the Thomas Jefferson Planning District Commission.

Stormwater, which originates from a precipitation event, be it rain or snow, is a notorious example of increased water quantity affecting water quality. As it flows over paved surfaces, lawns and other built environments before entering waterways, stormwater carries pollutants through runoff and contributes to erosion and flooding.

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Flooding can happen anywhere, and the key is to be prepared. The Federal Emergency Management Agency (FEMA) maintains and updates maps that depict the areas at highest risk of flooding.

Find your **flood map here** to help inform your decisions on safety preparation, housing and business operations.

Meanwhile, the Department of Conservation and Recreation oversees the Virginia Flood Risk Information System (VFRIS). Combining the FEMA data with localized data provides users with a Virginia-specific look at their flood risk.

Visit the Virginia Flood Risk Information System **here**.

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You may have heard the term "100 year flood," but do you know what it means? A house located within the 100 year floodplain has a 1% chance of flooding each year. Over the course of a 30 year mortgage, areas in the 100 year floodplain have at least a one in four chance of flooding.

Flooding of a shoreline residence in the York Watershed System. *Credit: CBNERR-VA.*

Case Study | Septic Tank Vulnerability

Approximately 88% of York Watershed System properties rely on septic systems, many of which are threatened by inundation (CCRM, 2024). Inundation, through various types of flooding and/or sea level rise, contributes to septic tank malfunction. Saturated soils and damaging saltwater intrusion compromise the infrastructure and efficacy of systems and their adjacent drainage fields. Flooded drainage fields filter less, leading to increased wastewater in natural water bodies (see **page 47**). Influxes of wastewater may impair a water body, making it unsuitable to swim or harvest fish and other aquatic organisms for consumption.

Failing and non-compliant septic systems are found throughout the York Watershed System. In 2008, $58 million in identified repairs to each were assessed in the six-county Middle Peninsula Planning District; as of 2020, $16.4 million in the Mattaponi subwatershed alone (**Mattaponi River Watershed TMDL Implementation Plan**) were identified. In *Figure 9*, septic repair "Hot Spots" are mapped, indicating areas with repeated occurrences of septic malfunction.

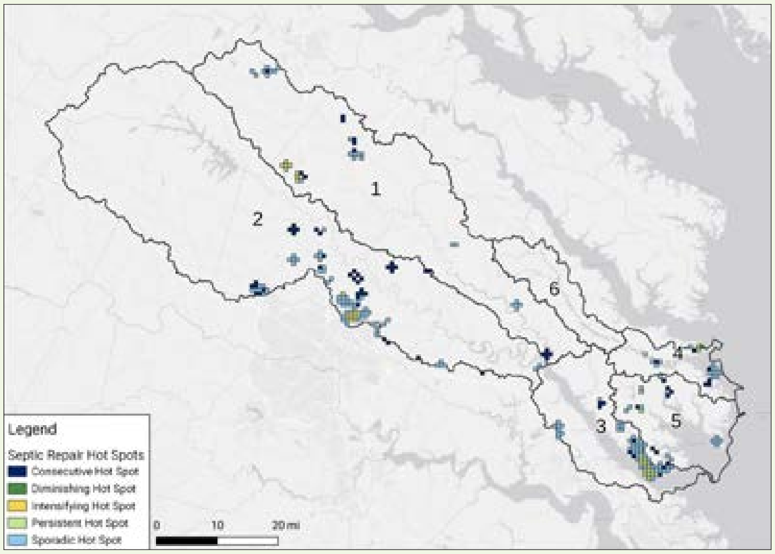


Figure 12. Septic hot spots by subwatershed. Legend details can be found in the source article, **Mitchell et al. 2021**.

There are **267** identified septic hot spots in the York Watershed System.

The Virginia Wastewater Data Viewer (CCRM-VIMS) helps examine patterns of septic system failure and forecast the effects of sea level rise on septic systems in Virginia. Using this tool, you can detect how often septic systems fail relative to surrounding areas and how often they flood. This information can be used to focus funding for septic system improvement or alternative wastewater treatment systems in areas of high failure or in areas where septic system improvement could enhance water quality.

More research within the York Watershed System is needed to understand the extent and impact of issues like septic failure on water quality, particularly given increasing severity of stressors like precipitation and sea level rise.

To help meet needs related to failing septics, the Middle Peninsula Planning District oversees septic and well assistance programs. As of August of 2023, their collective grants and loans, representing funding available for residents, totaled $3.8 million. To apply for related funding, residents are encouraged to register at **FighttheFloodVA.com** (see **page 26** for more details).

One measure of water quantity flowing through a watershed is streamflow, also called river discharge. Streamflow is the amount of water moving through a fixed point per unit of time. For example, 100 gallons of water per minute might be an estimate of streamflow. Recreationalists may reference streamflow in cubic feet per second.

After a large rain event, streamflow tends to increase significantly. This increase can lead to the movement of sediment, be it through erosion or deposition, as well as changes in water conditions, such as water temperature and downstream salinities.

Figure 13 depicts streamflow in two of the York Watershed System's main water bodies, the Pamunkey and Mattaponi rivers. While we see continuous peaks and valleys, indicative of large precipitation and drought events over short time scales, a look at the trends over larger time scales reveals a different story. Incidentally, within the York Watershed System, while rainfall is increasing (page 15), there is no apparent increase in streamflow.

Increasing trends in precipitation, driven by weather and climatic factors (see page 39 for a description on how these differ), are not echoed in relatively stable streamflow data due to additional and complex interactions between water use (of both groundwater and surface waters) and land use (see page 36 and factors listed there influencing nutrient and sediment loads).

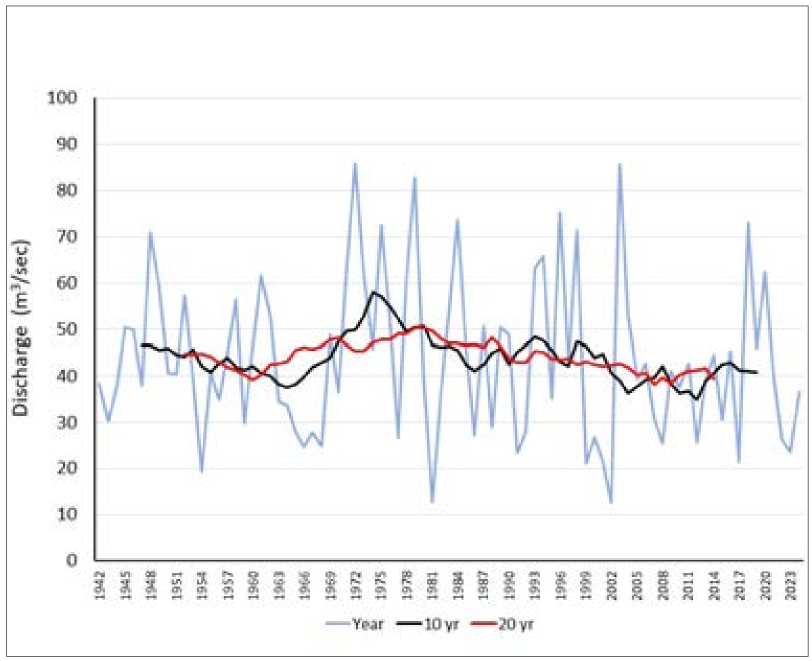


Figure 13. Combined Pamunkey and Mattaponi at RIM (River Input Monitoring) yearly streamflow, representing discharge in approximately 65% of the York Watershed System area. Eleven and 21-year central moving average trends are presented. RIM gauging stations, included in **Figure 11**, are operated by the United States Geologic Survey. *Data Source: RIM gauging stations 01673000 (near Hanover) and 01674500 (near Beulahville). Credit: William Reay.*

Notably, steady streamflow does not equate with zero erosion. As we saw on page 14, erosion throughout the System is significant. Moreover, lowered discharge has implications on fish spawning runs and water supply, among other impacts.

Increased demand for water within the York Watershed System has spurred plans for new intake and discharge of river water, potentially impacting System water quantity and quality. Determining the potential impact of planned intake and discharge on streamflow in System waters will require a data gap analysis, and related data collection.

Managing erosion and flooding through a combination of "natural and nature-based" solutions (aka green infrastructure) is gaining steam nationwide and has significant support in the Commonwealth (CRMP 2021, pg. 170). Natural and nature-based solutions restore or mimic natural features and/or processes native to the areas they occupy. They are championed not only for their abilities to help combat erosion and flooding, but as effective means toward improved water quality and habitat provision.

Examples of these restorative solutions are found throughout the York Watershed System on both small and large scales, and include, but are not limited to: rain gardens, bioswales, riparian buffers, permeable pavers, wetlands, sand dunes, oyster reefs and living shorelines (see the Case Study on page 25 for a look at the latter). Incidentally, these solutions represent, in large part, the Best Management Practices (BMPs) encouraged throughout the Chesapeake Bay region for improved water quality (see page 37 for more on BMPs). While some of these solutions may be more appropriate for a private residence, many can be implemented at larger scales. Solutions on public lands provide prime examples of benefits accrued to watershed residents and visitors alike.

Machicomoco State Park living shoreline. *Credit: Karen Duhring.*

An oyster reef is installed as a living shoreline in Mobjack Bay waters. *Credit: Aileen Devlin | Virginia Sea Grant.*

For the 101 on natural and nature-based features, please visit **NOAA's Natural Infrastructure Hub** and the **Center for Coastal Resource Management's Nature-Based Solutions Hub**.

Riparian buffers are vegetated areas situated adjacent to waterbodies. They help combat erosion by trapping sediments and holding banks in place. Moreover these forested areas intercept waters draining into waterways, effectively diminishing the concentration of sediments, nutrients, and pollutants in water bodies, all the while providing habitat for watershed wildlife. Tree canopy serves as an important indicator of riparian buffer presence.

The York Watershed System has approximately 95,250 acres of riparian buffers covering nearly 84% of the area suitable for buffers. Streams in Lake Anna's southern reaches offer some of the most viable opportunities in the System to increase riparian buffer coverage (see ***Figure 14***).

Funding to support riparian buffers. The Virginia Department of Forestry (DOF) aims to fill gaps in riparian buffer implementation and advance water quality improvement throughout the Commonwealth via its Riparian Forests For Landowners Program. This program covers the costs for riparian forest buffer installation and one year of maintenance for a broad range of landowners. Check out the details here.

Volunteers plant trees in the Pamunkey subwatershed to help establish a riparian buffer. *Credit: K. Myer.*

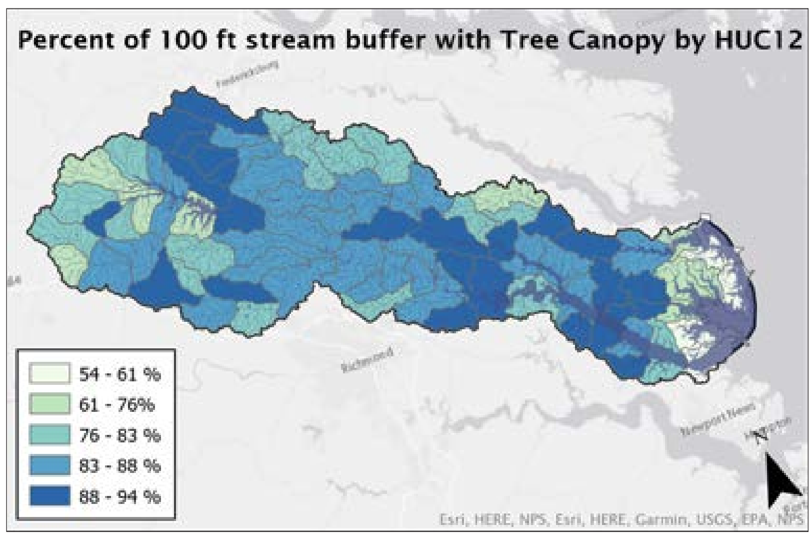


Figure 14. Concentration of riparian buffers in the York Watershed System, as represented by percent of 100 ft. stream buffer with tree canopy. *Data sources: Chesapeake Bay Program Office (CBPO), 2022. One-meter Resolution Land Cover Change Dataset for the Chesapeake Bay Watershed, 2013/14 – 2017/18. Developed by the University of Vermont Spatial Analysis Lab, Chesapeake Conservancy, and U.S. Geological Survey. Credit: Erin Reilly.*

Excess nutrients in Lake Anna are likely contributing to increasing numbers of Harmful Algal Blooms (more beginning on **page 42**). Exploring installation of more riparian buffers in those areas surrounding the lake currently lacking coverage, could help bolster ongoing remediation efforts.

Living shorelines are distinguished from riparian buffers by inundation frequency, vegetation type, resulting habitat and associated wildlife, as well as differing nutrient reduction capabilities; they are typically assessed with respect to length and width. These natural and/or nature-based features encourage the growth of native plants and animals, protecting and stabilizing land at the water's edge while allowing for natural processes to take place. Living shorelines are considered a win for people, planet and pocket as they help reduce human vulnerability to storms, can improve water quality, store carbon, provide habitat for wildlife, support fisheries, and represent a growing economic market.

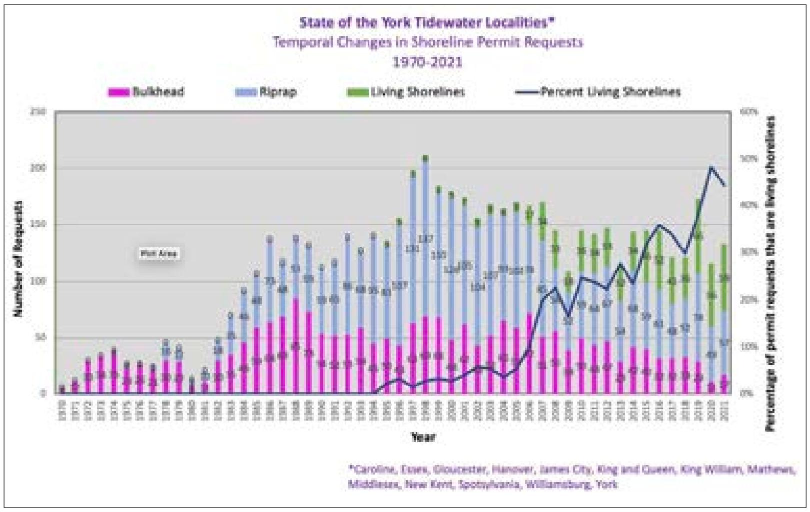
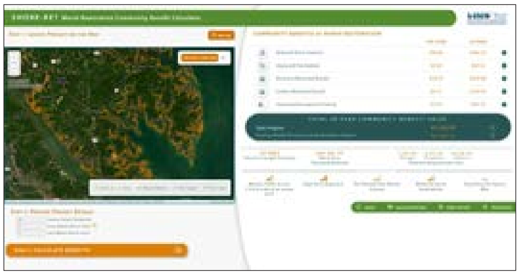


Figure 15. Changes in shoreline permit request numbers and ratios for three shoreline types within York Watershed System tidewater localities. *Data source: VMRC Habitat Management Division.*

Dig in on living shorelines with this storymap!

Completion of a living shoreline installation in York Watershed System tidewaters. *Credit: Consociate Media.*

Solutions that "harden" the coastline, like bulkheads or revetments, may be appropriate in places where there is high wave energy or existing built infrastructure. But this hardening comes at a cost. Hardened shorelines reflect wave energy which can lead to scouring at the base of the structure, impacts to neighboring properties, and loss and degradation of habitats. These static 'walls' also prevent marshes from moving landward with rising water levels, which results in future marsh loss (see page 8).



Just how much might people and pocket benefit from living shorelines? The SHORE-BET calculator provides one indication of the benefits living shorelines bring to communities.

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Shoreline permit trends in the System's Tidewaters (***Figure 15***) indicate a steady increase in applications for living shorelines since Virginia adopted the **Living Shorelines Act** in 2011, which established living shorelines as the preferred alternative for stabilizing tidal shorelines. During the same period (2011-2021), shoreline armoring (bulkhead and riprap revetment) permit requests declined, but continued to comprise the majority of requested projects.

Following the implementation of living shoreline legislation, other incentives, such as low-interest loans and cost-shares were developed to promote the use of living shorelines. In 2020, new legislation (**SB776**) was passed in Virginia requiring the use of living shorelines unless the 'best available science' indicates the approach is not suitable.

An analysis of tidal shorelines within the York Watershed System indicates that the System harbors more than 1,410 miles of shoreline suitable for living shoreline implementation (***Table 6***). The York River subwatershed maintains the most shoreline mileage with living shoreline potential. Shorelines recommended for living shoreline implementation are depicted in ***Figure 16***, a visualization of recommended shoreline management approaches in the System's tidewaters.

Notably, shorelines in the Pamunkey and Mobjack Bay subwatersheds are most subject to a suite of special considerations (e.g. requirements to protect natural features) that may necessitate alternative management strategies.

A hybrid shoreline at Williams Wharf Landing in Mathews County, VA. *Credit: D. Frantz*

Table 6. Miles of tidal shoreline within the York Watershed System suitable, as of 2022, for living shoreline implementation. *Source: Nunez et al. 2022*.

Subwatershed	Suitable living shoreline in miles	Suitable living shoreline miles as a percent of total miles assessed within subwatershed
Dragon Run	18.3	87.44
Mattaponi River	162.0	89.71
Mobjack Bay	417.2	78.83
Pamunkey River	179.8	78.80
Piankatank River	178.5	85.22
York River	458.6	89.91
TOTAL	**1,414.4**	**84.27**

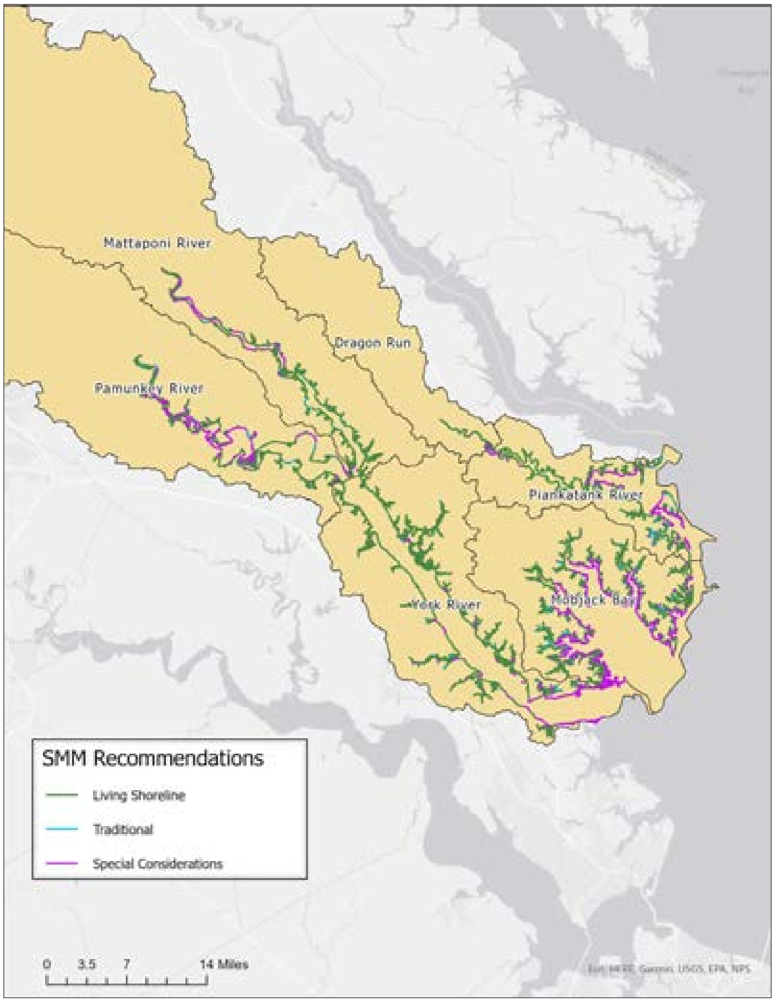


Figure 16. Recommended approaches to shoreline management within York Watershed System tidewaters based on the Shoreline Management Model (SMM). Approaches detailed include living shoreline implementation, traditional (e.g. bulkhead and riprap revetment), and special consideration (where at least one additional factor may complicate living shoreline presence and expert review is encouraged). *Source: Nunez et al. 2022*.

Protect your shoreline – effectively! Tips from the pros here. More resources on page 27.

Marty Ross and Dan Hopkins; their living shoreline in the background. *Credit: CBNERR-VA.*

Case Study | A (Living) Labor of Love

Marty Ross and Dan Hopkins purchased a house on Cedarbush Creek in 2002. No more than a year in, they watched from their backyard as a house vanished from sight in Hurricane Isabel's tidal surge. In the years that followed, they'd watch waves hit the bottom of the steep cliff that their house was perched on, and observe the sediment wash away into the creek. Today, that eroding silt gets trapped behind an oyster shell sill they built with their own hands.

"When we knew we wanted to build a dock we talked about how vulnerable the bank was and what we should do; we'd seen how much land it takes to do a gentle grade – and we don't have that much room here," said Dan as he motioned to the house, approximately 50 feet from the bank. Plus, grading, he said, "would have been very expensive, and this was something we just thought we could do ourselves, and was such a fun project."

That project began in 2017, as Marty and Dan picked up 25 bags of oyster shells in their small Honda and set to work positioning them in front of their eroding bank. Having tested the waters, so to say, with these initial bags, the couple ordered pallets next. Once on their property, Marty would pick the bags up from the pallets and send them down a homemade chute to Dan, who set to work stacking them. All in all, nearly 1,300 bags were used to create the sill along more than 100 feet of shoreline. Given the tides, they'd only have an hour a day to work, but the rest in between was welcomed.

The work developed in stages. First the oyster shell bags, followed by truckloads of sand to backfill, and finally, dozens of marsh grass plugs to help hold it all in place.

"As soon as we put the bags in we started to see little fishes and turtles and crabs – everything on the inside of the sill. It was so exciting to see that the habitat was populated almost immediately," said Marty, whose initial concerns about the oyster bags breaking and harming wildlife have been completely assuaged. No broken bags, no injured wildlife.

Instead, oysters and mussels have begun to colonize, holding the bags of shell in place even in the highest of tides and strongest of surge. Behind the sill, two layers of healthy spartina (marsh grass) are helping break wave action. Their shoreline now represents a healthy marsh habitat.

As early adopters – among the first private-home shoreline projects in Gloucester County – Marty and Dan were too early in the game to receive the financial assistance that now exists for these types of projects (through programs like the Virginia Conservation Assistance Program and Fight the Flood, see below and page 27), though they say they saved money by doing the work themselves. Moreover they consider themselves fortunate as academic research tools (like this one), developed after they constructed their shoreline, have since confirmed that a living shoreline was indeed the solution best suited to meet their goals for the location they lived in.

"There was so much we didn't know; I think everything we've learned – and we've been so happy because we had fun physically doing it, we had a great time seeing what happened, and we love that it was something that developed in stages," Marty said. She added that they now have something beautiful to look at. "We are proud of our shoreline project and its success!"

"Fight the Flood connects property owners to funding opportunities through – low interest loans and grants. Eligibility varies from program to program. In some cases grants are available for low-income households and in other cases loans are approved. The availability of funds can vary, with some available immediately and others taking years to access. The Fight the Flood team takes the assistance request responses and works to identify possible grant eligibility, notifying applicants as funds become available."

- Taylor Ovide, Coastal Resilience Planner, Middle Peninsula Planning District Commission

Not quite sure what type of shoreline would work best for your property? Visit the **Shoreline Decision Support Tool** from the Center for Coastal Resources Management.

Not ready to install a living shoreline on your own? Curious about the contractors operating in this space? **Fight the Flood** is a marketplace designed to connect homeowners with experienced contractors able to design and implement flooding solutions, including those natural and nature-based. Funding opportunities are also available. At time of press, upwards of $31.5 million in loans and grants have been distributed throughout the region via this program.

A few extra CALLS TO ACTION!

- **Bear witness.** Help inform sea level rise science and decision-making by documenting your experiences with flooding, via:
  - Sea Level Rise Phone App - courtesy Wetlands Watch
- **Protect your yard.**
  - Rainscape; work with the rain to prevent flooding.
  - Plant native plants for the protection of shorelines, water quality and wildlife.
- **Consider living shorelines.**
  - More on them here.
  - Get an expert assessment by Virginia SEAS, the Virginia Department of Conservation and Recreation's Shoreline Erosion Advisory Service.
- **Explore financial assistance** for installation of your natural and nature-based solution.
  - Fight the Flood connects property owners to grant and loan funding.
  - The Virginia Conservation Assistance Program (VCAP) provides assistance to property owners through a cost-share structure.
- **Keep your Wetlands Boards accountable.** Wetlands Boards have the decision-making power to protect wetlands and encourage alternatives to shoreline hardening. Do you know who your wetlands boards members are? Are they being trained in related decision making?
  - Shoreline Management Handbook - a good resource for wetlands boards, developed to assist in decision making
- Septic tank on the fritz? Not sure? **Review, repair and replace as needed**- and test your waters!
  - Learn more about septic tanks in this Virginia Department of Health guide.
  - Virginia Household Water Quality Program, offering Well Water Testing & Drinking Water Clinics


A shoreline in the Mobjack Bay subwatershed. *Credit: Aileen Devlin | Virginia Sea Grant.*

OUR WATER QUALITY

Water quality monitoring with the Chesapeake Bay National Estuarine Research Reserve in Virginia. *Credit: CBNERR-VA.*

OUR WATER QUALITY

We've explored how our landscape is developing, and the challenges that new and existing development face with respect to increasing water quantities, particularly with respect to precipitation and sea level rise. Next we'll dig a little deeper into changing water quantities and explore what they mean for our water *quality*.

But first, waters reach us and renew themselves as a result of the water cycle.

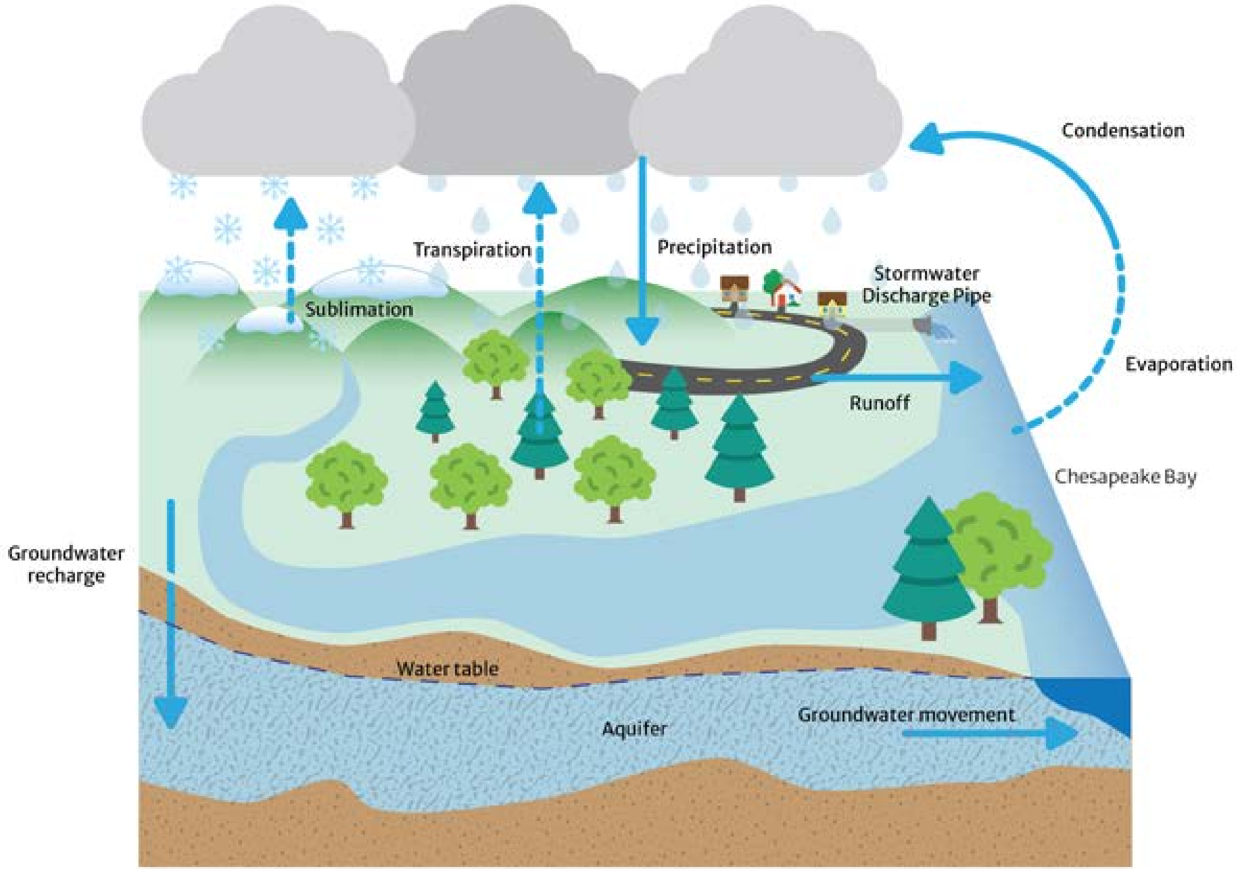


Figure 17. A simplified water cycle. *Credit: Green Fin Studio.*

Water moves through various stages within the water cycle (***Figure** 17*). Fundamentally, it transitions from water bodies to air through evaporation, from plants to air through transpiration, and back to water bodies, plants and land through precipitation.

The precipitation that makes its way over land directly into a water body is called surface water runoff. The precipitation that filters through surface sediments (e.g. soils, rocks) becomes soil moisture and groundwater, recharging existing supply. All the while, groundwater flows toward larger water bodies through a water table and confined aquifers. Aquifers contain groundwater in what are essentially large matrices of water bearing material until it ultimately discharges into a surface water feature. These groundwater contributions, in combination with surface water runoff, often represent the focal point of water quality interests in a watershed.

The simplified water cycle described is often more nuanced, complicated by geologic features that impact of water movement. Accordingly, groundwater transport occurs over variable pathways with varying timescales, and may range from days to thousands of years. Moreover, groundwater extraction disrupts natural cycling for purposes ranging from residential to industrial. ***Figure 18*** details a generalized cross-section of the Virginia Coastal Plain, and the features therein that impact groundwater movement.

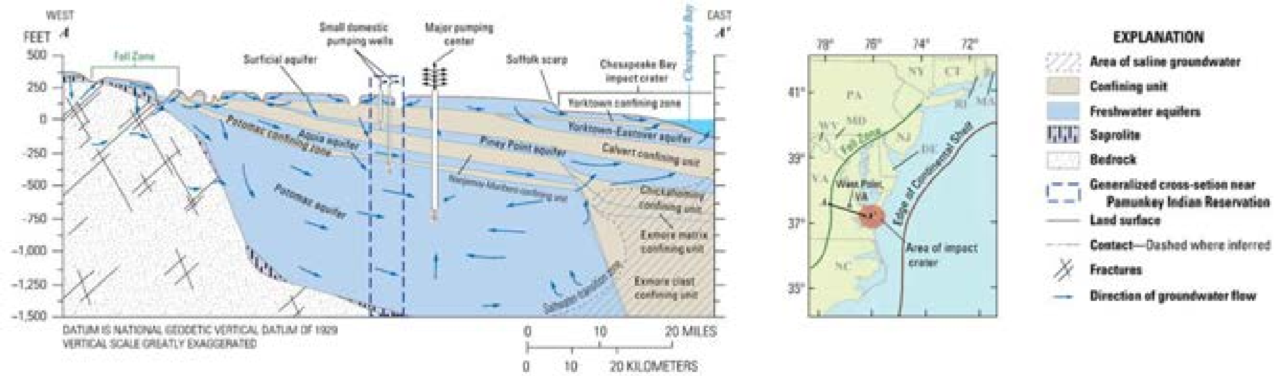


Figure 18. Generalized hydrogeologic cross section and directions of groundwater flow in the Virginia Coastal Plain under current conditions. *Adapted from* **Foster et. al, 2024**.

Virginia Department of Environmental Quality's **Water Withdrawal website** has important information related to both groundwater and surface water permitting.

Increased demand for water within the York Watershed System represents an emerging threat to water supply with implications on, among other issues, subsidence. Continued research and science-based solutions, both policies and innovations, are needed to explore and address this depletion.

Within the York Watershed System, water supply for agriculture, industry and domestic/commercial use in urban areas is primarily derived from the Potomac Aquifer. Groundwater wells complement this supply in more rural areas, where they provide water for domestic use. Notably, the Potomac Aquifer is recognized as a depleting and vulnerable resource. As such, areas within Virginia's Coastal Plain, including a majority of the York Watershed System's counties, are considered Groundwater Management Areas requiring permits for large quantities groundwater withdrawal.

Nutrients and sediments contribute to the character of a water body, defining what can live and grow in the waters. While natural processes, like the water cycle, introduce each into our waters (see, for example, **York River Physical Oceanography and Sediment Transport**), water quality issues arise when they are introduced at rates that the natural world is unprepared to mitigate.

HRSD, which serves the York River subwatershed, plans to return treated wastewater to the Potomac Aquifer as part of its **Sustainable Water Initiative for Tomorrow, or SWIFT**. Slated for York River implementation mid-2030s, this initiative will recharge the aquifer with treated water that would otherwise be discharged into the York River.

Maintaining moderate "loads" of nutrients (i.e. nitrogen and phosphorus) and sediments is a vital part of maintaining water quality and ensuring watershed health. The challenge? Human activities associated with development, land use practices, and population growth can lead to increased loads of nutrient and sediment inputs to water bodies.

Sediment-filled stream at a future construction site within the York Watershed System. *Credit: CBNERR-VA.*

The York River Basin (see page iii), for example, experiences chronic water quality issues driven by excessive loads of sediment and nutrients. Eutrophication, a process resulting in excessive plant and algal growth, low dissolved oxygen, and reduced water clarity, often results. Efforts to reduce nutrient and sediment inputs, including through agricultural practices, shoreline restoration, and wastewater treatment improvements, have been partially offset by increases in nutrient sources associated with continued development (see ***Figure 19***).

Case Study | The WIP

The amount of nutrients (i.e. nitrogen, phosphorus) and sediments entering the water is called a Load. Loads can come from point sources, like wastewater treatment facilities, or nonpoint sources, such as runoff from a farm field or a suburban lawn. The Chesapeake Bay Program models these loads using information such as land cover, monitoring data and installed Best Management Practices (e.g., living shorelines, riparian buffers, tree plantings). Load information can help decision makers choose where to invest funds to reduce nutrients.

Reductions in nutrient quantities, through the development of Total Maximum Daily Loads (TMDL), are a key part of implementing the Chesapeake Bay Watershed Agreement. Signed in 2014 by the Chesapeake Executive Council, with representatives from the six states in the Bay watershed and Washington, D.C., this agreement contains ten interrelated goals reflecting major watershed initiatives including, but not limited to, Climate Resiliency, Sustainable Fisheries, and Healthy Watersheds. A TMDL is a calculation of the maximum amount of pollution a waterbody can sustain and still meet water quality standards. TMDLs are developed for rivers and streams based on carrying capacity of an area, as well as its associated inputs.

To help define specific reduction targets for localities and use sectors (e.g. agriculture, development), Bay states created respective Watershed Implementation Plans (WIP). Each state's plan describes the reductions in nutrients and sediments necessary to achieve target TMDLs. Further, each plan outlines best management practices (BMPs) that can be implemented toward reductions. BMPs target a variety of societal sectors, ranging from cover crop use to shoreline management, and septic pumping to forest planting.

The Commonwealth of Virginia is on Phase III of its Watershed Implementation Plan (WIP). The practices and policies outlined in this plan were developed to help achieve load reductions by 2025 that account for, and address, climate change impacts. **Visit the York Watershed System's Phase III WIP here** (beginning on page 110).

While there has been progress in reducing nutrients within the York Watershed System, it has not yet reached the goals established in the Commonwealth's Phase III WIP (see ***Figure 19a***). There have been reductions from the agricultural and wastewater sectors, but these have been partially offset by increasing development and associated waste water in the System.

The take home point? On the whole, estimated nutrient and sediment loadings within our watershed system have not shown a significant long-term trend.

Figure 19 a-c. Total modeled loads of nutrients and sediments over time and by use sector in the collective York, Piankatank and Mobjack Bay basins (see **page iii** for geographical depictions). ***Source: Chesapeake Bay Program, 2020. Chesapeake Assessment and Scenario Tool (CAST), version 2019. Chesapeake Bay Program Office; last accessed March, 2024.***

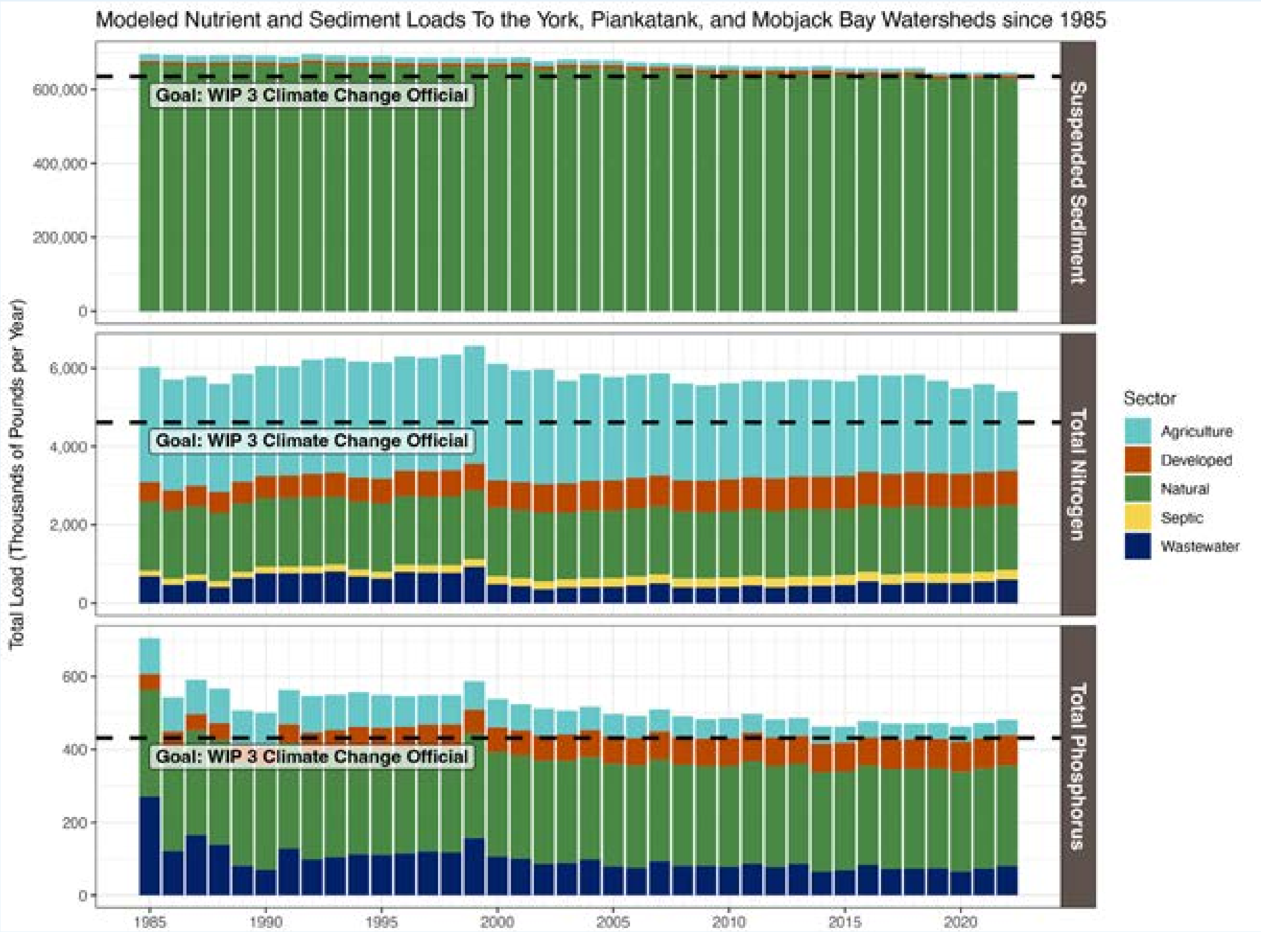


Figure 19a. Nutrient (nitrogen and phosphorus) and sediment loads to the York, Piankatank and Mobjack Bay basins by use sector since 1985. WIP III goal indicated by the dotted black line.

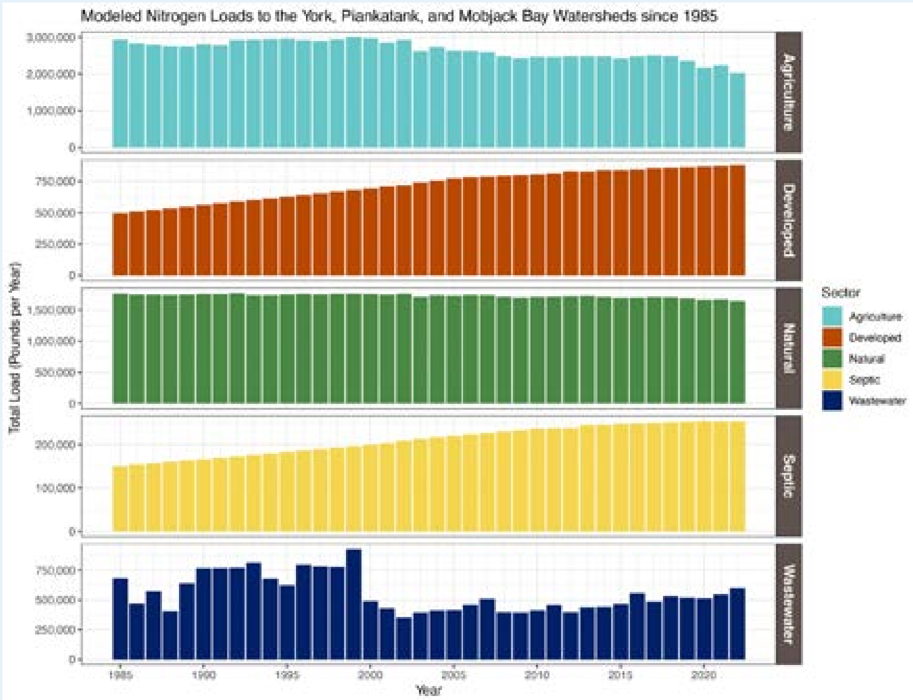


Figure 19b. Nitrogen loads to the York, Piankatank and Mobjack Bay basins by use sector since 1985.

For more on nutrients in the watershed, check out this *USGS project page*, featuring a storymap on nontidal loads and trends.

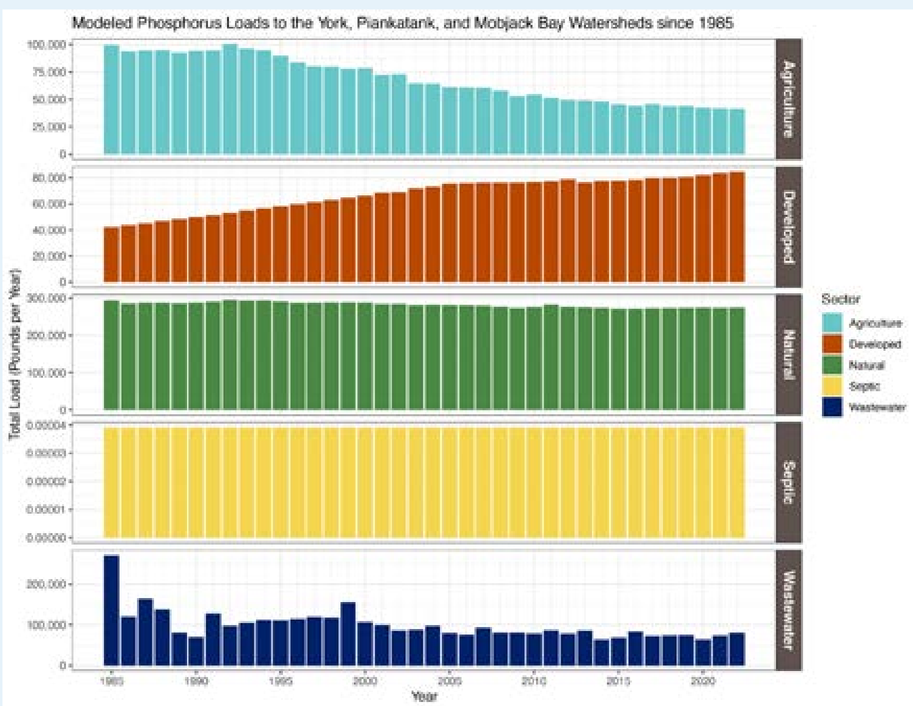


Figure 19c. Phosphorus loads to the York, Piankatank and Mobjack Bay basins by use sector since 1985.

For more on System trends, visit the York Tributary Summary: A summary of trends in tidal water quality and associated factors 1985–2018).

St

Despite not reaching the goals established in the Commonwealth's Phase III WIP (page 33), York River nutrient and sediment loads, stemming from the Mattaponi and Pamunkey rivers, remain relatively low in comparison with other major tributaries in the Bay (*Figure 20*).

Multiple factors contribute to a wide range of nutrient and sediment loadings observed in the Chesapeake Bay. Variations in these loadings are influenced by watershed characteristics including: hydrogeologic framework (e.g. geology, topography, groundwater flow patterns and residence times), soil types, distribution of waterbodies and stream network patterns, surface water residence time, land and water use patterns, and anthropogenic land activities, in addition to weather and climate patterns.

The York Watershed System's innate characteristics, such as its waterbody distribution and topography, may contribute to its lower, and relatively stable, nutrient and sediment loadings over time (pages 34–35). The point at which these characteristics will no longer compensate for increasing loads resulting from anthropogenic use and activity, is unknown. To help combat a tipping of the scales, land use management practices must be adopted widely.

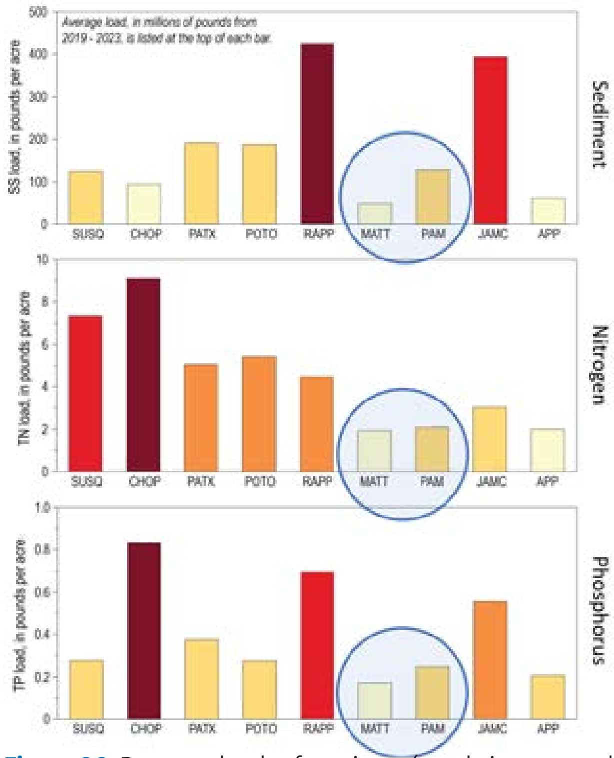


Figure 20. Per–acre loads of nutrients (total nitrogen and phosphorus) and sediments across major Chesapeake Bay tributaries: Susquehanna, Choptank, Patuxent, Potomac, Rappahannock, Mattaponi, Pamunkey, James, and Appomattox (2019 – 2023 average). York Watershed System tributaries (Mattaponi, MATT, and Pamunkey, PAM) highlighted in blue. *Adapted from: **USGS RIM data presentation to the Integrated Trends Analysis Team, June 2024**.*

Eager for more? For a deep dive on York Watershed System water quality, read **Water Quality within the York River Estuary.**

York Watershed System nutrient and sediment loads measure among the lowest of any gauging station located in the major Chesapeake Bay Tributaries when adjusted for flow and area (Zhang et al. 2023). But why? Further research is necessary to resolve the influence of waterbody distribution and topography, and the point at which land use activity can no longer be compensated by these natural features.

Land use management practices, often referred to as best management practices or BMPs, have been documented to improve water quality in agricultural and developed watershed settings. Commonly used types of agricultural management practices include crop nutrient management plans, conservation tillage, forest buffers and grass filter strips, soil and water conservation plans, and animal waste management systems. In urban/suburban settings, recommended practices include urban nutrient management plans, infiltration-based and stormwater retrofits and detention ponds, reclaimed water use, enhanced onsite and centralized wastewater treatment, and stream restoration.

Table 7 depicts nutrient and sediment loads stemming from four types of land use where no land use management practice is implemented.

Land Class	Doubled Cropland	Pasture	Developed	True Forest
Sediment	2.21	0.08	Highly variable	0.07
Total Nitrogen	30.87	11.78	13.90	1.68
Total Phosphorus	1.87	0.81	0.85	0.08

Table 7. Representative annual averaged land use nutrient (pounds per acre) and sediment loads (tons per acre) without benefit of management practices used in the Chesapeake Bay Program's (CBP) Phase 6 Watershed Model. Note that nutrient loadings represent export rate to a stream or other waterbody, whereas sediment metrics represent edge-of-field loads. *Data Source: Chesapeake Bay Program Phase 6 Watershed Model, Section 2, Average Loads Final Model Documentation for the Midpoint Assessment. May 11, 2018.*

We all have a part to play. While the innate nature of our watershed has, to date, helped keep our nutrient and sediment loadings stable over time and among the lowest in the Bay, increases in loadings will continue as our population within the System grows and infrastructure is built to accommodate it. Collectively, we can help combat these increases by **1) implementing best management practices** on our property, be it yard or agricultural field (**a guide found here!**), and **2) encouraging sustainable development through accountability and support** of practices that allow for development in concert with the natural landscape.

Cattles graze on seasonal annuals that provide high quantities of high quality feed without pesticide use. *Credit: Hanover-Caroline Soil and Water Conservation District.*

Residents of Covenant Woods and community members attend an educational event to learn about BMPs installed at Covenant Woods. *Credit: Hanover-Caroline Soil and Water Conservation District.*

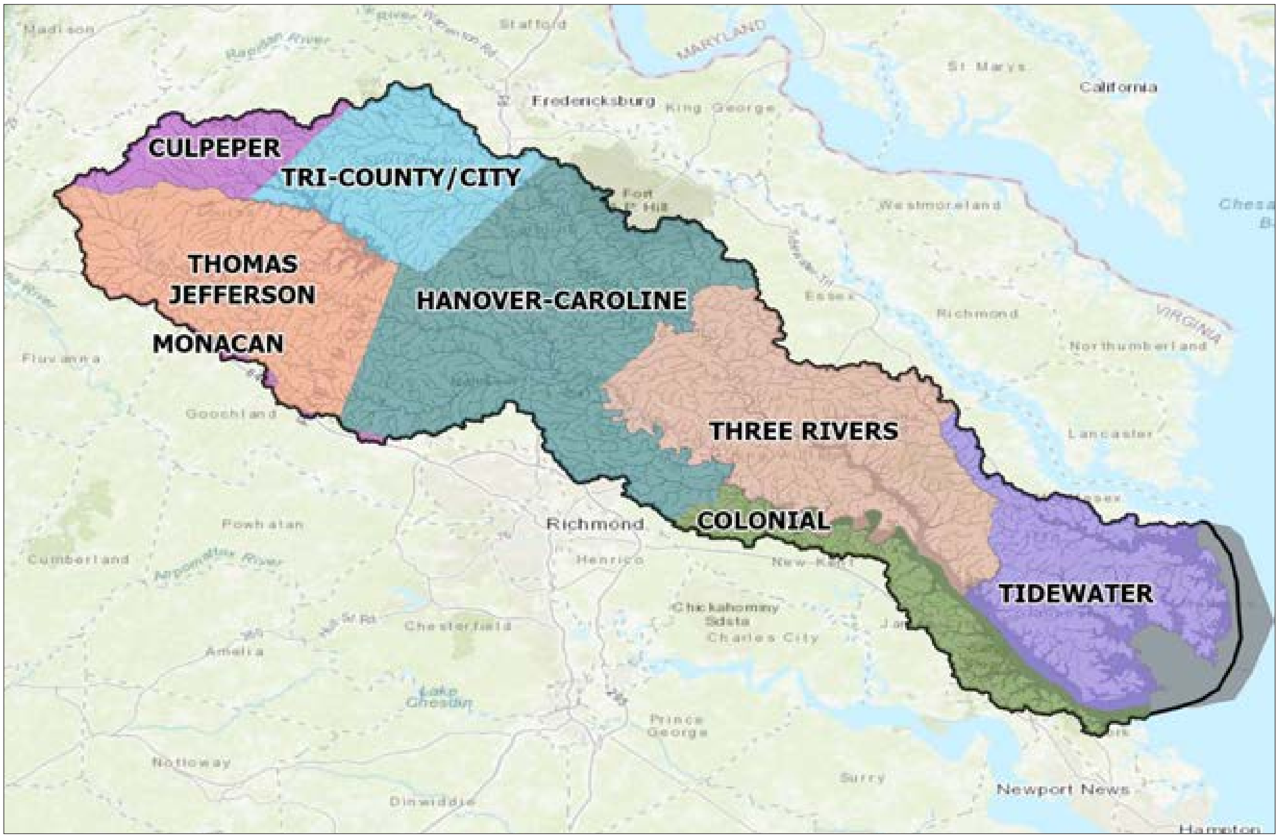


Figure 21. Soil and Water Conservation Districts within the York Watershed System.

Soil and Water Conservation Districts (SWCDs) provide programming and plans focused on land use management. Moreover, they provide assistance for best management practice (BMP) implementation through cost-share programs. The York Watershed System includes 8 SWCDs.

Learn more about your Soil and Water Conservation Districts here.

Colonial Soil and Water Conservation District offers homeowners stormwater information at a local market. *Credit: Colonial Soil and Water Conservation District*.

Compounding the effects of additional nutrients and sediments in our waters, are increases in air and water temperatures. Notably, these increases occur along different time scales.

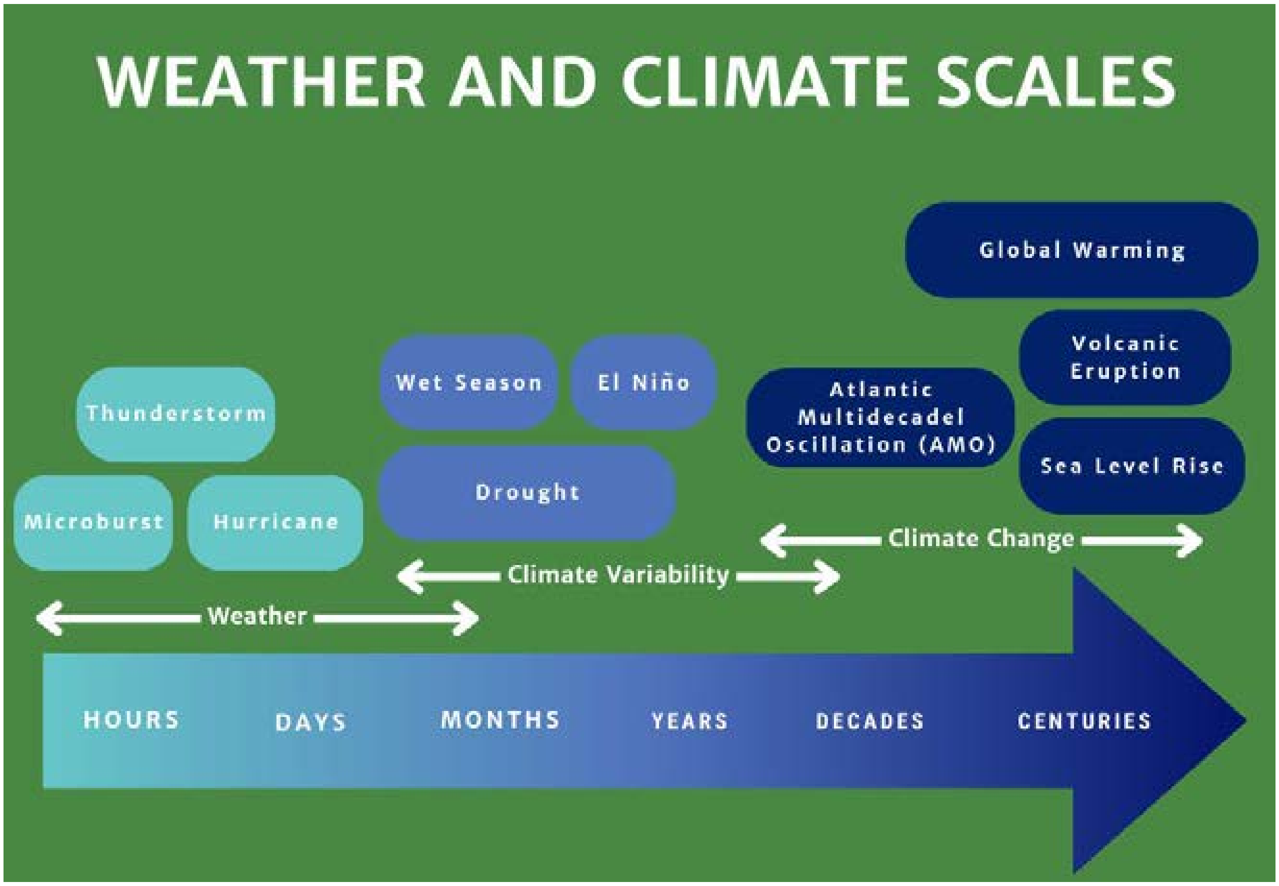


Figure 22. A graphical interpretation of atmospheric change over different time scales. *Credit: William Reay and Stephanie Letourneau.*

As their respective names suggest, long term events manifest over long time scales and are reflective of climatic changes; short term events occur over short time scales and are reflective of changes in weather (see ***Figure 19***).

Both types of events are experienced in the York Watershed System's air and water. Some associated implications are addressed on the following pages.

Short term weather event in the York Watershed System. *Credit: C. Gonzalez.*

Air temperatures within the watershed show extended periods of rising and falling over the course of many decades, with lows in the 1920s and 1970s, and highs in the 1950s as well as presently. These trends are likely related to global climate patterns, such as the Atlantic Multidecadal Oscillation. Overall, however, air temperatures within the watershed have increased over time, a clear indication of warming climatic trends (*Figure 23*).

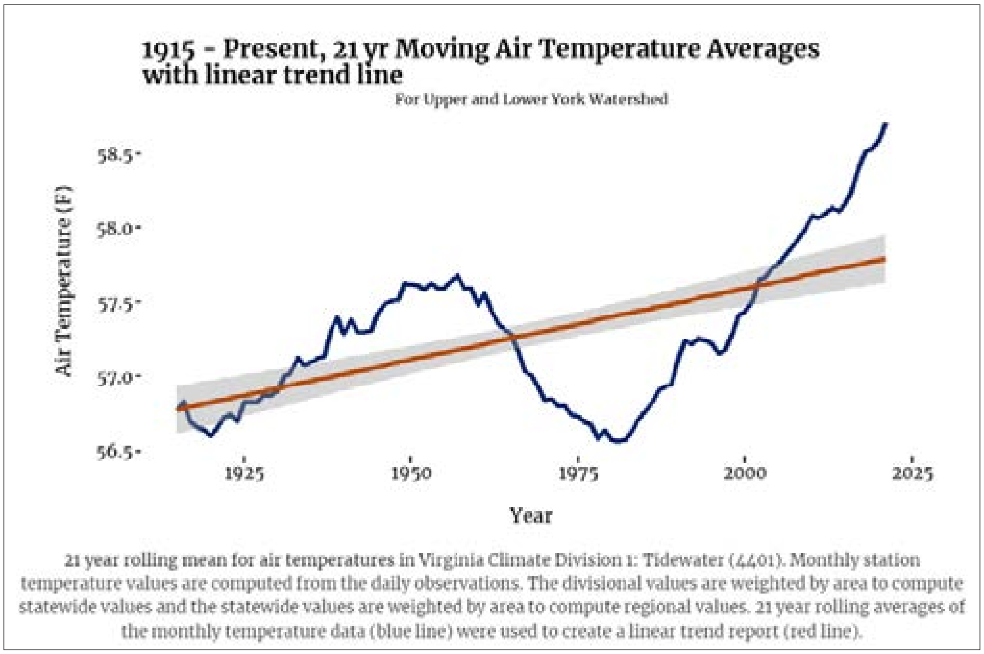


Figure 23. Moving air temperatures averages from 1915 to 2025 (projected) with linear trend lines for upper and lower York Watershed System combined. Source data: National Centers for Environmental Information.

Likewise, York Watershed System waters have experienced increasing temperature trends, over both long and short term scales (*Figure 24*).

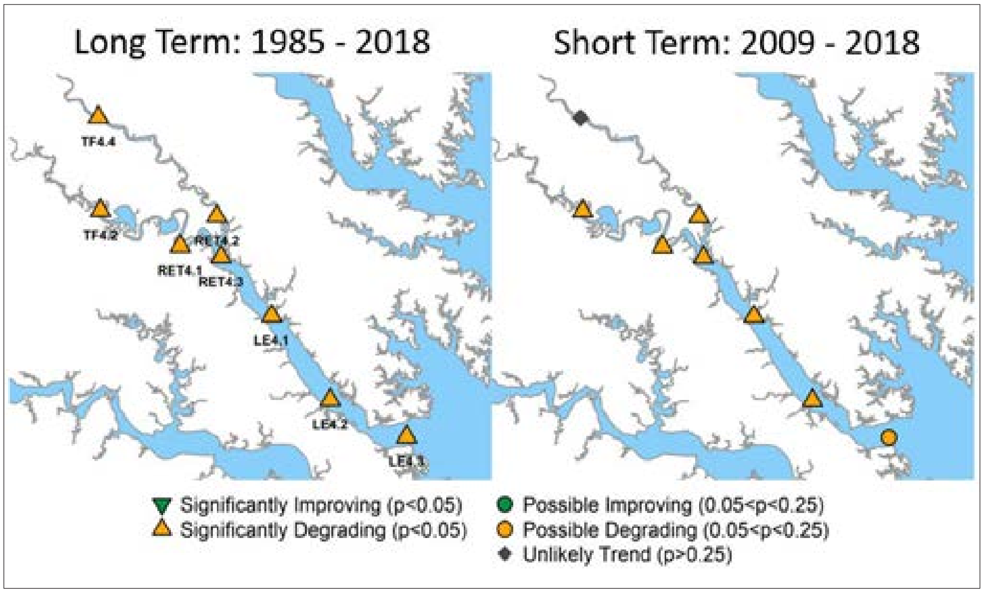


Figure 24. Chesapeake Bay Program mid-channel monitoring locations demonstrating annual York Watershed System trends in surface water temperatures on long (1985–2018) and short (2009–2018) term scales. Several stations report significantly degrading trends indicating significant surface water warming. Source: Tidal Trends in Water Quality; York 2018 Tributary Summary.

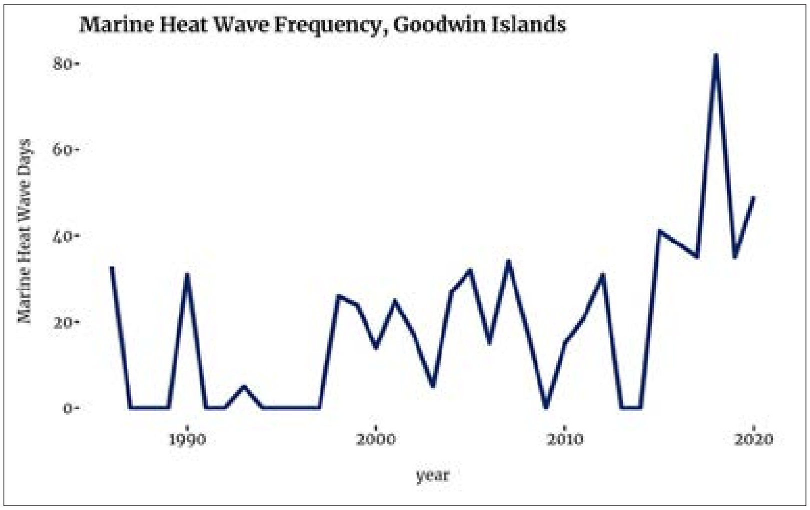


Figure 25. Increasing trend in marine heat waves from 1998-2020 at Chesapeake Bay National Estuarine Research Reserve in Virginia's water quality monitoring station located at Goodwin Islands, York River (VECOS, CDMO, Mazzini and Pianca, 2022).

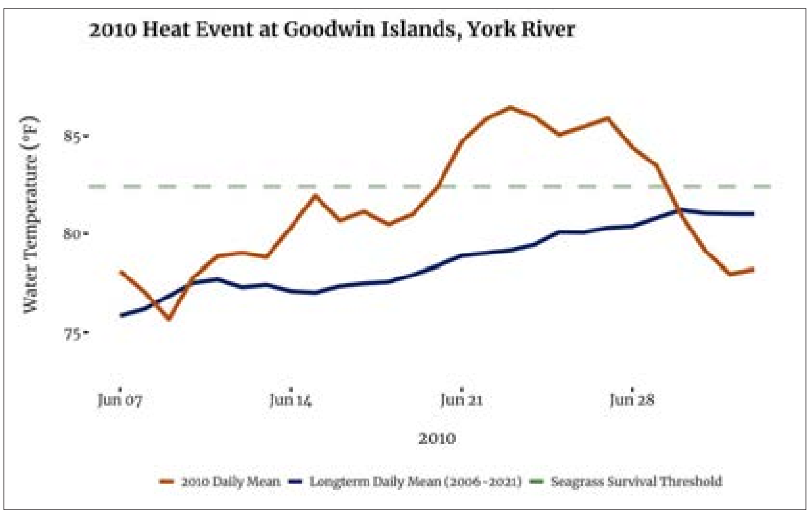


Figure 26. Example of short-term heat event as shown by Chesapeake Bay National Estuarine Research Reserve in Virginia water quality monitoring data, collected at Goodwin Islands, York River in 2010. Seagrass survival threshold depicted by dashed gray line (https://vecos.vims.edu).

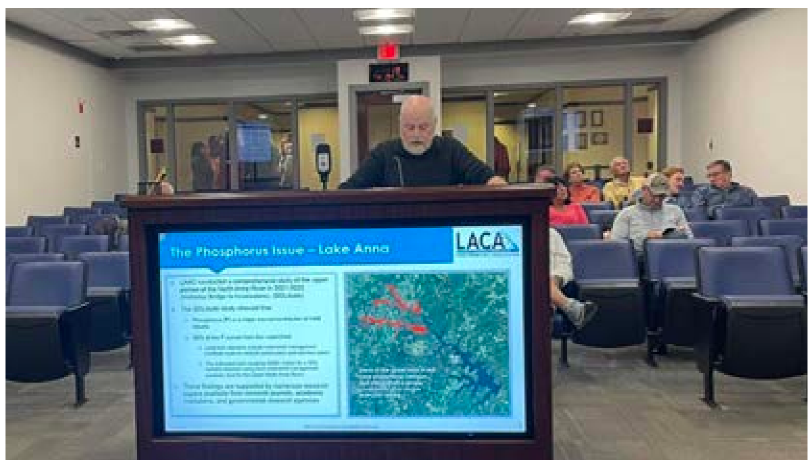
While the occurrence of short term temperature events (anomalies at extremes, e.g. heat wave, cold snap) is not abnormal, their increasing frequency is cause for concern. Short term water temp trends (on the order of days-weeks) are influenced by a combination of factors, such as air temperature, wind-driven advection, precipitation and runoff. Marine heat waves are short term temperature events that occur when sea surface temperature at a given locale exceeds its historical temperature threshold for five consecutive days or more. Marine heat waves have been detected at many locations in the Chesapeake Bay at increasing frequencies, including in York River tidal waters. ***Figure 25*** depicts the increasing frequency of marine heat wave events at the Goodwin Islands, located at the mouth of the York.

Despite the short duration of these heat events, their impact to flora and fauna may be significant. For instance, ***Figure 26*** depicts a 2010 marine heat wave event in the Goodwin Islands. Water temperatures during this event exceeded the short term temperature thresholds for a local eelgrass, *Zostera marina*. Following this event, *Z. marina* experienced a 76% loss of bottom coverage (Shields et al. 2019). Reductions in vital habitat for York species, storm surge protection for the eroding island shorelines, and carbon capture capacity, all benefits of healthy seagrass populations, were associated with this loss in coverage. See page 64 for more on the impacts of increased temperatures on seagrass.

Harmful algal blooms (commonly referred to as HABs) refer to the growth of algal communities associated with toxins and/or other harmful compounds that negatively impact aquatic life and the ecosystem. Some HABs can also threaten human health through occupational or recreational exposure to affected waters or consumption of contaminated seafood. HABs are a result of an imbalance in the ecosystem, which may manifest as abnormal and extreme water temperatures and/or nutrient concentrations. Short-term HAB events have been increasing in frequency within the York Watershed System for various reasons specific to location, a trend that has been observed by researchers and residents alike over the long term. These increases have the potential to compromise human health, impact natural resources, and/or negatively impact recreation and tourism (see page 45 and 46 for more on these impacts).

A harmful algal bloom in the lower York River. *Credit: CBNERR-VA*

Continued and robust monitoring in Lake Anna is necessary to definitively elucidate HAB causation. The ongoing collaboration between state government and community science efforts, via the Lake Anna Civic Association's Water Quality Committee, demonstrates the need for increased support of participatory science.



Harry Looney, Water Quality Coordinator for Lake Anna Civic Association, presents to the Lake Anna Advisory Committee meeting on possible ways to mitigate algae blooms in Lake Anna's upper reaches. *Credit: Lake Anna Life & Times.*

In the upper watershed, high levels of nitrogen and phosphorus have historically plagued Lake Anna. This excess of nutrients, or eutrophication, stemming from sources like livestock and fertilizers, contributes to elevated algal growth and ultimately, HABs. Evidence stemming from community science monitoring indicates that an increase in these nutrients over time may be contributing to a dramatic increase in HABs in recent years.

Meanwhile, in the lower York River, blooms of the phytoplankton species *Margalefidinium polykrikoides* were reported beginning in the 1960s (Zubkoff et al. 1979; Marshall and Egerton 2009). Since the early 1990's, these blooms have occurred on a near-annual basis (Marshall 1996; Marshall and Egerton 2009; Mulholland et al. 2009, 2018). *Alexandrium monilatum*, a HAB species that occurs later in the summer, has routinely bloomed throughout the lower Chesapeake Bay, including the York, starting around 2012 and continuing to this day.

Figures 27 and 28 depict short-term HAB events at each end of the York Watershed System with different visualizations. Each event is marked by an increase in chlorophyll, a fluorescing pigment necessary for algal photosynthesis. Accompanying each graph indicating excessive chlorophyll concentrations at water quality monitoring stations, are satellite and aerial views of algal blooms near these stations to offer additional perspective. Using remote sensing technology, like satellites, chlorophyll can be used to detect HABs from space. Each satellite image portrays data on chlorophyll concentration, illustrating high concentrations associated with HABS by using color gradients. Changes in color likewise reflect high concentrations of algae in the aerial photos. The dark brown and bright green patches, respectively, are made up of millions of algae cells that are concentrated enough to change the appearance of these surface waters.

Figure 27 a-c. HABs in the upper York Watershed System: Lake Anna waters, located within the Pamunkey subwatershed.

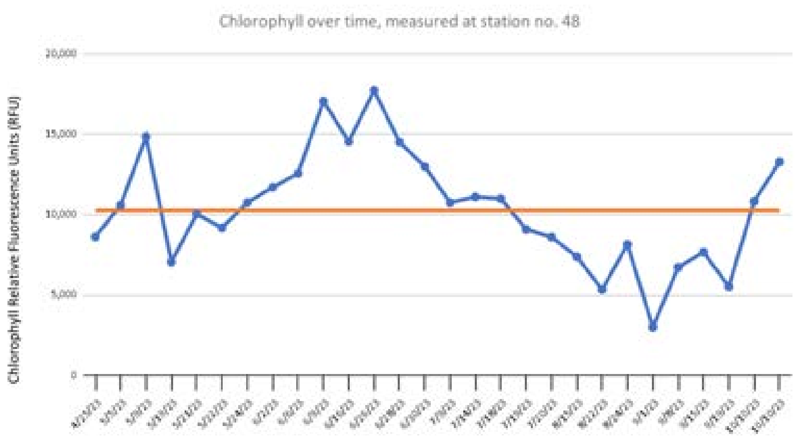


Figure 27a. Example of 2023 algal bloom event in Lake Anna's upper north waters as indicated with chlorophyll using Lake Anna Civic Association's Water Quality Monitoring Program data. Station mean (orange trendline) reflects average from 2020-2023.

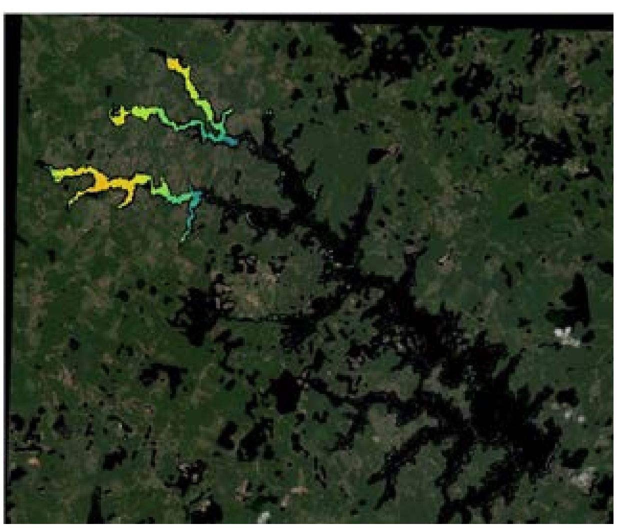


Figure 27b. Satellite image of a bloom in Lake Anna's upper north waters on 8/23/23. *Data source: SENTINEL-2A MSI, Courtesy* ***Copernicus Program****, modified by NOAA CoastWatch.*

Figure 27c. Image of Lake Anna surface during a HAB event in July of 2023. *Credit: Lake Anna Civic Association.*

Figure 28 a-c. HABs in the lower York Watershed System: lower York River subwatershed waters.

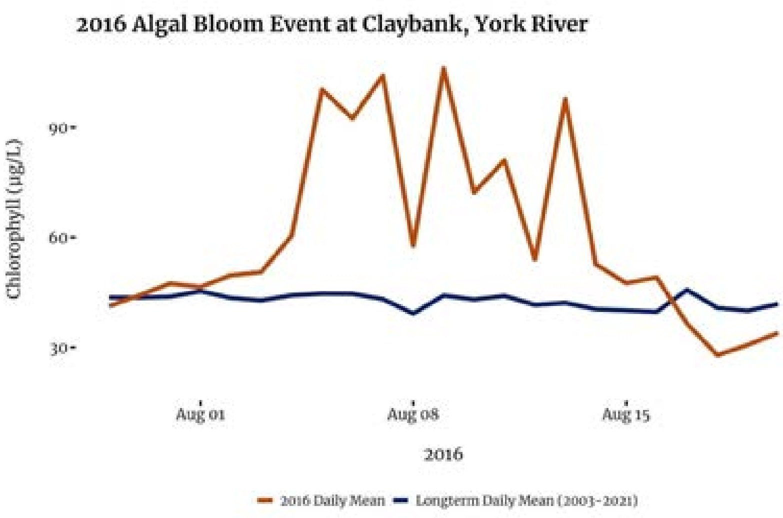


Figure 28a. Example of 2016 algal bloom event as indicated with chlorophyll at CBNERR-VA water quality monitoring station located at Claybank, York River, VA (**https://vecos.vims.edu**).

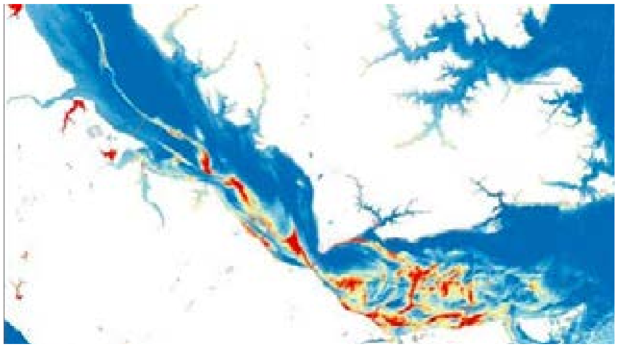


Figure 28b. Satellite image of bloom in the lower York River on August 29, 2016. ESA Sentinel-2a satellite sensor. In this blue-to-red display, blue represents water relatively clear of chlorophyll while red indicates higher chlorophyll content. ***Copernicus** Sentinel data (2016)/ESA.*

Figure 28c. Aerial image of bloom in York River, August 10, 2022. *Credit: S. Mapes.*

The **CEOS COAST Application Knowledge Hub** is a coastal information portal that aims to illustrate and visualize the impact of climate change and short term events by leveraging satellite data. Chesapeake Bay is one of two focus areas for this application, which is global in scope! Watershed practitioners can use this tool to help understand not only water quality impacts, but issues like flooding vulnerability.

HABs vary in size, color and severity depending on the species in bloom and the conditions of the water. Temporal variation among them exists as well, dictated by seasonal changes and interannual variability in water quality.

Common to each however, is the ability to threaten human, and/or aquatic, health and well-being. Specifically, toxins and pathogens associated with HABs have negative implications, both direct and indirect, for the actual and perceived ability to recreate in coastal waters and enjoy coastal fare. HAB species that bloom in the lower York River, for example, can be harmful to fish and shellfish, critical commercial and recreational fisheries. They also create a surface scum that can alarm recreational boaters.

Target harmful microalgae in the York River subwatershed

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Pseudo-nitzschia delicatissima												
Karlodinium veneficum												
Prorocentrum minimum												
Chatonella subsalsa												
Akashiwo sanguinea												
Margalefidinium polykrikoides												
Alexandrium monilatum												
Other genera: *Dinophysis, Karenia*	TBD											

Table 8. Harmful York River subwatershed microalgae and their occurrence by month. *Credit: Savannah Mapes, VIMS.*

HAB occurrences thus have the potential to reverberate throughout our local economy. Within the York Watershed System, this impact is felt most in Lake Anna, site of persistent cyanobacterial blooms that often lead to boating and swimming advisories or closures, impacting quality of life and the recreational industry, among others.

An aerial photo of a lower York HAB event. *Credit: S. Mapes.*

Water color a little off?
Think it could be a bloom?
Report a HAB to Virginia's Department of Health ***here*** by submitting your bloom photos.

From 2018 through 2024, multiple areas among the northernmost portions of Lake Anna, comprising approximately 4,400 northern acres of the 9,600-acre lake, were under a Virginia Department of Health (VDH) recreational advisory for at least one reporting period due to cyanobacteria blooms (***Figure 29***). The predominant cyanobacteria species in the northern parts of Lake Anna during this timeframe included seven species known to produce toxins (see underlined and bold font species in ***Figure 30***); among them, *Raphidiopsis raciborskii* and *Dolichospermum spp.*, the two most prevalent. Due to VDH recreational advisories issued for two consecutive years (2019 and 2020), the Virginia Department of Environmental Quality (DEQ) listed several northern areas of Lake Anna as impaired in their Final 2022 305(b)/303(d) Water Quality Assessment Integrated Report (see page 47).

> ***"We tube and we play in a lake all the time, but these days, we've got the harmful algal blooms. And that's become a huge issue for the folks that live there because they can't use the water; and the folks that visit, they're concerned about the water... You can't swim in it because of these algae blooms. There are 50 businesses or so located on Lake Anna, from restaurants to marinas, to golf cart shops. I mean, it's affecting every business."***
>
> *– Kevin Marshall, Spotsylvania County Commissioner*

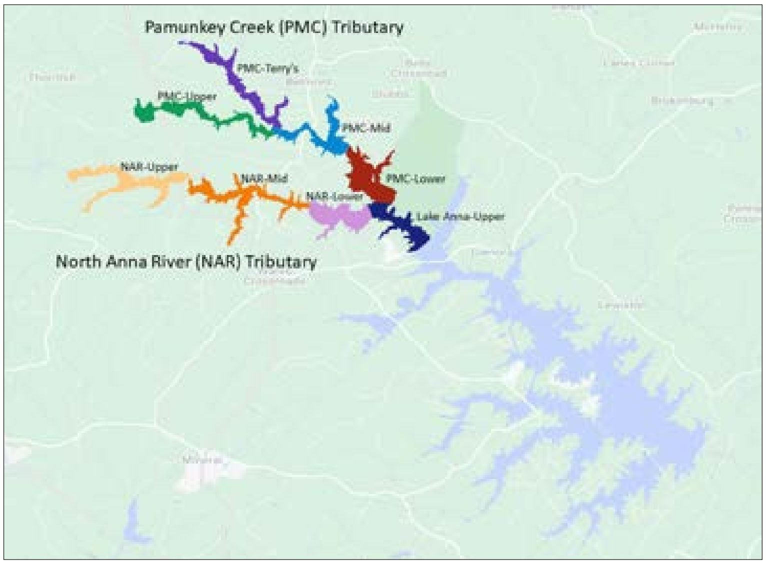


Figure 29. Map of Lake Anna segments with at least one advisory from 2018–2024. *Credit: Lake Anna Civic Association.*

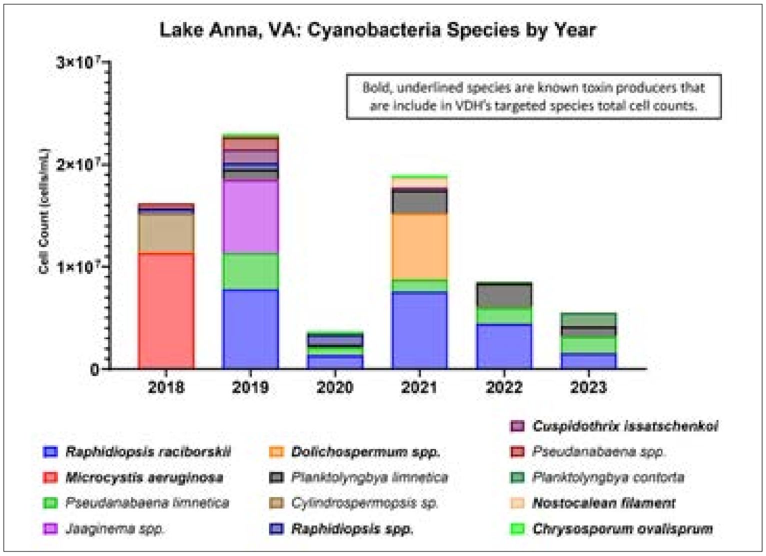


Figure 30. Lake Anna Cyanobacteria species counts by year. *Data source and credit: Lake Anna Civic Association.*

Just how big of an economic impact are HABs having in the York Watershed System? More valuation studies are needed!

Unfortunately, HABs are not the only contaminant within the watershed, nor are they the only emerging threat.

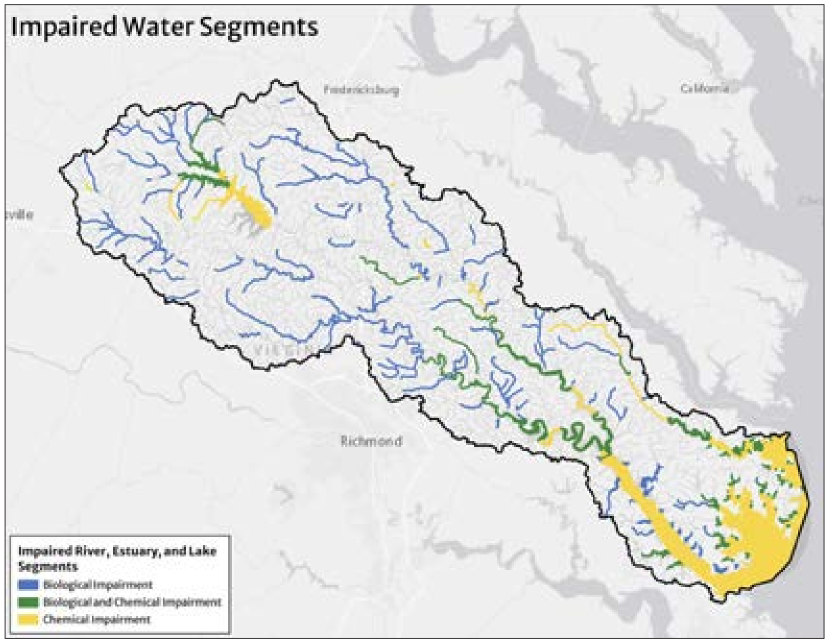


Figure 31. Impaired Water Segments in the York Watershed System, grouped as biological, biological and chemical, or chemical. 2022 Final 305(b)/303(d) Assessment Unit GIS dataset. Virginia Department of Environmental Quality, Office of Ecology, Water Monitoring & Assessment Program. Last Accessed May 2024.

Biological contaminants, like *Escherichia coli (E. coli)*, have long been present in our swim/fish/wade-worthy waters, though continue to jeopardize water quality as a result of factors like livestock waste, pet waste, and compromised septic systems. From 2015 to 2020, 87% of river miles* and 22% of estuaries** surveyed in the York, Pamunkey and Mattaponi subwatersheds by Virginia's Department of Environmental Quality (DEQ) were impaired due to bacteria which restricted uses, including recreation and fish consumption. DEQ reported these numbers in their 2022 Integrated Report, linked in the resource box below.

Chemical contaminants in watershed waters have taken many shapes and forms over the years. Emitted by countless sources, they may have been the result of an industrial discharge, or perhaps carried in stormwater from neighborhood streets to streams. In the York, Pamunkey and Mattaponi subwatersheds, mercury and polychlorinated biphenyls, or PCBs, are monitored by DEQ. In their 2022 water quality report (linked below), the agency reports that 6% of river miles* surveyed from 2015 to 2020 were impaired due to mercury in fish tissue, while 8% were impaired due to PCBs in fish tissue. Meanwhile, within estuaries**, 21% of the areas surveyed were impaired due to mercury in fish tissue, and 92% impaired due to PCBs in fish tissue. Both mercury and PCBs are known to cause adverse human and environmental health effects.

The numbers reported above are expected to change slightly in DEQ's FINAL 2024 Water Quality Assessment Integrated Report, due out 2024. This report assessed

Virginia Department of Environmental Quality's (DEQ's) Final 2022 Water Quality Assessment Integrated Report contains the information on impaired waters described above in section 4.3, page 98. (Note that the Final 2024 report can be accessed at this same site once released.) For details on specific creeks, see the Virginia DEQ Fact Sheets for Impaired Waters in 2022.

data from 2017 to 2022. While the percentage of river miles impaired by bacteria, mercury and PCBs remained the same, as did the percentage of impaired estuarine areas due to mercury in fish tissue, the percentage of impaired estuaries areas due to bacteria and PCBs grew to 31% for bacteria, and 93% for PCBs.

Both biological and chemical contaminants can enter waterways at single, distinguishable sources, referred to as **point source pollution**, or through a variety of indistinguishable pathways and sources, referred to as **nonpoint source pollution**. *Figure 29* illustrates point-source discharge locations for both biological and chemical contaminants within the York Watershed System; each permitted through the Virginia Pollutant Discharge Elimination System (VPDES) and regulated to minimize impact.

Urban, agricultural, and forested areas may represent nonpoint discharge sources (see ***Figure 4 on page 4*** for a recent depiction of these areas in the System). Unlike point sources, most nonpoint sources do not require Commonwealth permits. One example of a nonpoint source area that is permitted for its discharge, is a Municipal Separate Storm Sewer System, commonly referred to as an MS4. MS4s are defined by their network of drainage systems that carry nonpoint source pollution via stormwater runoff directly to natural bodies of water. MS4 boundaries are fluid and dependent on population density; in the 2019 Phase III Watershed Implementation Plan, 13 MS4s were identified in the York Watershed System.

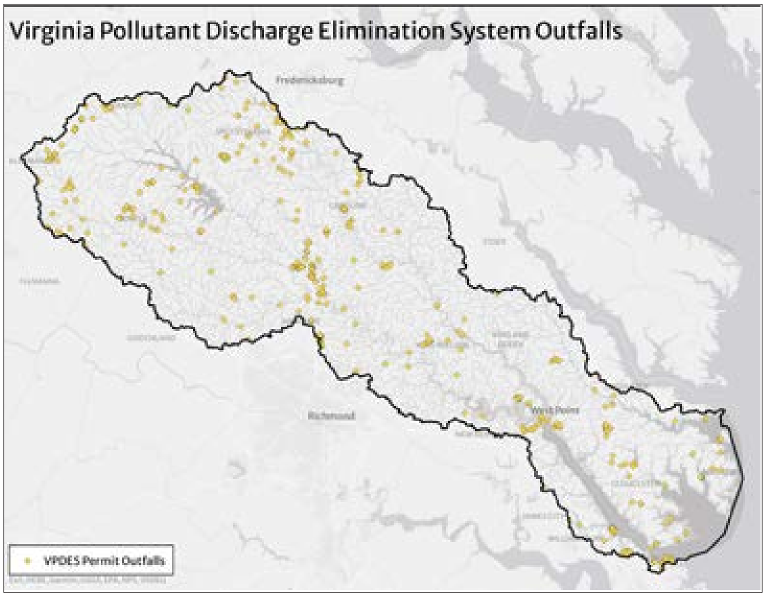


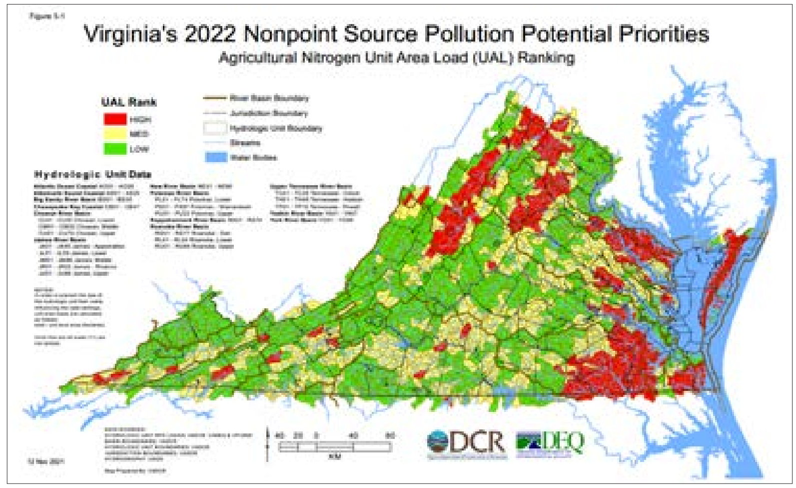
Figure 32. Point discharge locations permitted by Virginia's Department of Water Quality within the York Watershed System. *Source data accessed May 2024, through the Virginia Pollutant Discharge Elimination System (VPDES).*

Like point source discharge locations, MS4s are regulated to minimize impact through reductions in nutrient and sediment loadings. The diffuse and varied nature of other nonpoint source pollution is difficult to regulate and does not afford this same control. Curbing the System's nutrient and sediment loadings thus requires concerted efforts to minimize the impact of nonpoint source pollution. Unregulated tools, like best management practices (page 37), are thus critical to maintaining and improving the System's water quality.

* Where river miles, based on the National Hydrography Dataset and calculated using the centerline of a flowing waterbody, are distinct from estuarine waters.

** Where estuarine waters, determined using the Chesapeake Bay Program's Segmentation Scheme, are distinct from the flowing water bodies used in river mile calculations.

In the Nonpoint Source Assessment section (Chapter 5) of its Final 2022 Integrated Report, Virginia's Department of Environmental Quality ranks areas by their nonpoint-source contributions to nutrient and sediment loads. Visit the document, and its 2024 draft on the **Integrated Report website here**.



Ships docked at Yorktown on the York River. *Credit: C. Gonzalez*

Sewage, graywater, bilge water, solid waste (trash) and hazardous waste represent types of discharge from vessels that can contribute to nonpoint source pollution in our waters. While discharge is regulated by the U.S. Coast Guard and Environmental Protection Agency (EPA), a discharge permit is not required until a vessel exceeds 79 feet in length, at which point it becomes a point source. Given present use by recreational, research, commercial and military interests, demonstrated increases in recreational boating nationwide, and cruise line interests in York River passage, quantifying the current impact of both point and nonpoint source vessel discharge within System waters, and modeling the potential impact of increasing discharge, including any effects on water quality and natural resources, is merited.

Chemical contaminants have entered our waterways from point and nonpoint sources for decades, but only recently have we started to explore and understand the persistent and prolific nature of those associated with synthetic materials.

Case Study | PFAS: Pervasive and Prolific

Per and polyfluoroalkyl substances, commonly called PFAS and notoriously known as "forever chemicals," are gaining awareness in the collective conscience and have been classified with the U.S. Environmental Protection Agency (EPA) as an emerging contaminant. Commonly used in products for their water resistant, heat tolerant, and non-stick/non-stain properties, PFAS are found everywhere from carpets and couches, to frying pans and floss, and are often present around military bases and airports because of their use in firefighting foam. Their "forever" properties allow them to endure in the environment, infiltrate our water supply, and bioaccumulate, or build up over time, in our bodies and those of watershed fish and wildlife. Various adverse health effects have been linked to PFAS exposure.

PFAS has been detected in multiple locations throughout the York Watershed System. Two of these locations exhibit excessive PFAS contamination (see PFAS contamination in the U.S.). At Fort Walker, untreated groundwater measures have indicated levels of a PFAS contaminant (PFOA) that exceed the U.S. EPA's 2024 maximum contaminant levels for drinking water by more than 100 times; at the Naval Weapons Station in Yorktown, another contaminant (PFOS) has reached 33 times more than its EPA allowance. Testing at other sites within the watershed has indicated elevated levels, though none exceed those found at the military compounds (see DEQ's Statewide PFAS Sampling Dashboard, and VDH's PFAS Sampling Dashboard).

Visit Virginia Department of Health's PFAS & Health and/or HRSD's Approach to Managing PFAS for tips on what you can do about forever chemicals.

Credit: **HRSD**.

Of course, synthetic materials themselves are also persistent and prolific, appearing in countless forms within our watershed as marine debris. From cigarette filters and food wrappers, to plastic bottles and bags, to fishing line and pots, each enduring and processed object impacts our waters, the life within them and the lives that depend on them in countless ways.

?! Did you know Virginia has a marine debris reduction plan? Check it out here.

While in Virginia, balloons and crab pots (see page 88) have garnered focused attention, perhaps no manifestation of marine debris is cultivating more notoriety of late as are microplastics. Originating from sources like cosmetics, plastic bottles, and synthetic fibers, these inconspicuous particles have been found in the waters we swim and the food we eat, an indication of necessary action. But the solutions remain elusive, and we're not quite sure just how severe the issue is. The type and scale of action required is contingent on increased study.

Fortunately, a host of people from all angles and sectors of society are keeping tabs on our water quality so that we can confidently enjoy watershed waters, or mobilize around their rehabilitation. Your neighbor might be among these water quality monitors; perhaps you're next?! Roll up your sleeves as part of these member groups to help keep watch on the state of our waters!

"Despite the growing interest in microplastic research and the evident data gap, securing funding for microplastic and nanoplastic monitoring programs remains a significant challenge."

– Bongkeun Song, Professor of Marine Science, Chair of Ecosystem Health Section, Virginia Institute of Marine Science

More research within the watershed is needed to understand the extent and impact of contaminants like PFAS and microplastics, as well as their intersection with climate change and increasing development. Baseline studies can help inform targeted solutions, like awareness campaigns and other consumer outreach.

Do you adore a debris-free shore? Join the annual Virginia Waterways Cleanup, August through November.

Avoid a balloon festoon. Help prevent balloon litter, one of the most common forms of debris on our shores, with tips from this Virginia resource.

Staff with the Chesapeake Bay National Estuarine Research Reserve in Virginia haul marine debris they've found while conducting field research in the York River. *Credit: CBNERR-VA.*

Case Study | Water Quality Monitoring – in, by and for Communities

Community members take part in a number of water quality monitoring efforts within the watershed, many of which contribute to Virginia Department of Environmental Quality's (DEQ) integrated assessments summarizing state water quality conditions, as well as U.S. Environmental Protection Agency (EPA) datasets. Notably, Virginia is one of the only states that has codified using community-collected data in their state reporting.

Nine community groups monitoring 134 stations in the York Watershed System submit data to the **Chesapeake Monitoring Cooperative** via the **Chesapeake Data Explorer**.

- RiverTrends began in 1985 and works with volunteer monitors to collect water quality data throughout Virginia. Guided by the Alliance for the Chesapeake Bay, which provides training, equipment and technical support to volunteers, data collection includes: observational data, water temperature, dissolved oxygen, pH and water clarity – with some regionally dependent indicators. Monitors follow strict protocols, and typically collect on a monthly basis, year-round.
- Lake Anna Civic Association's (LACA) Water Quality Monitoring Program has been evolving since 2002 and presently engages in three main projects. The Legacy Water Quality Monitoring & Sampling project is tightly coordinated with DEQ; as a certified, Level 3 monitor, LACA's data collected as a part of this program can be used in regulatory efforts. The Cyanobacteria Monitoring and Sampling project focuses on the problematic cyanobacteria issues found in the upper lake region tributaries; the data and information generated from related research and analysis is providing several potential paths forward to fight the cyanobacteria issues Lake Anna residents are experiencing. Virginia Save Our Streams, the third major project, is an Izaak Walton League effort currently focused on monitoring at three stations; participation requires certification.

Middle Peninsula Master Naturalists at a river monitoring site. *Credit: Alliance for the Chesapeake Bay.*

A member of the Lake Anna Civic Association samples Lake Anna waters for baseline water quality metrics. *Credit: CBNERR-VA.*

Programs like RiverTrends and LACA's Water Quality Monitoring Program come together through the Chesapeake Monitoring Cooperative. This initiative offers a suite of technical support services to community monitoring programs exploring water quality and benthic (bottom dwelling) macroinvertebrates, including training opportunities, data interpretation and troubleshooting. The cooperative's Data Explorer houses all of the data collected by member community monitoring groups, which translate (at time of print) to more than 820,000 data points; upwards of 2,300 stations; 7 Bay jurisdictions; and 116 organizations. All Explorer data is publicly accessible and informs the Chesapeake Bay Program as well as Virginia state agencies.

Water quality monitoring efforts ultimately help inform recreation guidance. Swimming or fishing? Before jumping in the water or frying that catch, **know before you go!** Visit the following websites for information on the waters you plan to recreate in and on, and turn to page 87 for more resources on safe fish consumption.

- **Wanting to swim or eat that fish?**
  - Visit: How's My Waterway? for information on swimming and fishing
  - Check out: Virginia Department of Health's Swimming Advisories and Monitored Beaches Map when you want to take a dip
- **Want to stay clear of HABs?** Visit: Virginia Department of Health Algal Bloom Surveillance Map

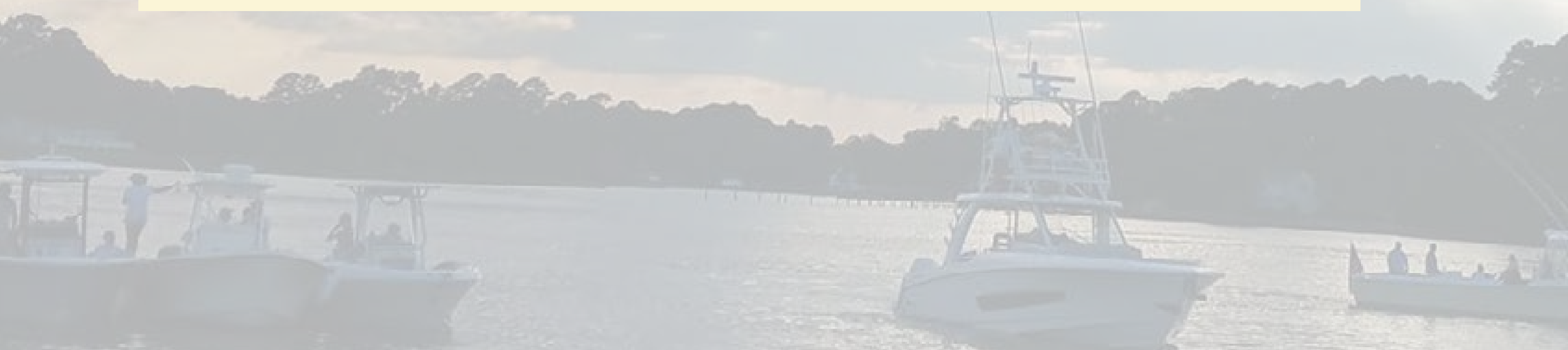
Beachgoers at Haven Beach in Mathews County. *Credit: Virginia Water Trails.*

Hey! What about my drinking water? Virginia's Cooperative Extension hosts Well Water Testing & Drinking Water Clinics, details here. Learn how to use tests kits and interpret the results for insight into your tap water. Test for iron, manganese, nitrate, lead, arsenic, fluoride, sulfate, pH, total dissolved solids, hardness, sodium, copper, total coliform bacteria and *E.coli* bacteria.

Monitoring is one way to take action on water quality – but there are plenty of others.

A few extra CALLS TO ACTION!

- **Become a member of the** York River and Small Coastal Basin Roundtable, a forum for information sharing and collaboration among water quality and conservation-minded stakeholders
- Nominate a waterbody for monitoring by Virginia's Department of Environmental Quality
- **Pump Out and Repair.** On a septic system? To ensure that wastewater doesn't back up in your yard and get washed into waterways, make sure you have your septic system pumped out or inspected at least every five years.
- **Scoop the Poop!** Pet waste contributes to the bacterial impairment of our waterways. Help keep our waters clean by cleaning up after furry friends. Bag it and bin it while on walks and once it reaches your law – before rainwaters wash it into our recreational waters.
- **Goldilocks that Grass.** Excessive nutrients in waterways may stem in part from over-fertilizing your lawn and/or garden. Test your soil to ensure you're adding the most appropriate and effective amounts of fertilizer to your yard.
- **Dispose with Discretion.** Storm drains are a surefire way to contribute to chemical pollution in our waterways. Likewise, using household drains to dispose of chemical waste can not only impact groundwater and our water supply, but damage piping. Check with your county or this Virginia Department of Environmental Quality site for options on hazardous material disposal. Not sure what qualifies as hazardous? Explore this list.
- **Be a clean boater.** Know the regulations on discharge and disposal.
  - EPA's Recreational Boater's Guide to Vessel Sewage
  - USCG Boater's Guide to the Federal Requirements for Recreational Boats



Boats at Williams Wharf Landing in Mathews County.
Credit: Donna Fisher Frantz.

THE RESOURCES WE STEWARD

Flowering seagrass (*Ruppia maritima*) is examined in York River waters. *Credit: CBNERR-VA.*

THE RESOURCES WE STEWARD

St

Water quality undeniably influences the character of the plants, animals and cultures native to the York Watershed System.

These resources, be they natural, cultural, or one in the same, , have been stewarded and cultivated by indigenous peoples since time immemorial. In turn, European settlers, enslaved and free African Americans, and later immigrants from around the globe would call this System home, each developing their own unique tie to the land and water around them; a tie that would be reflected through countless cultural practices and artifacts, some of which we continue to manage into present day.

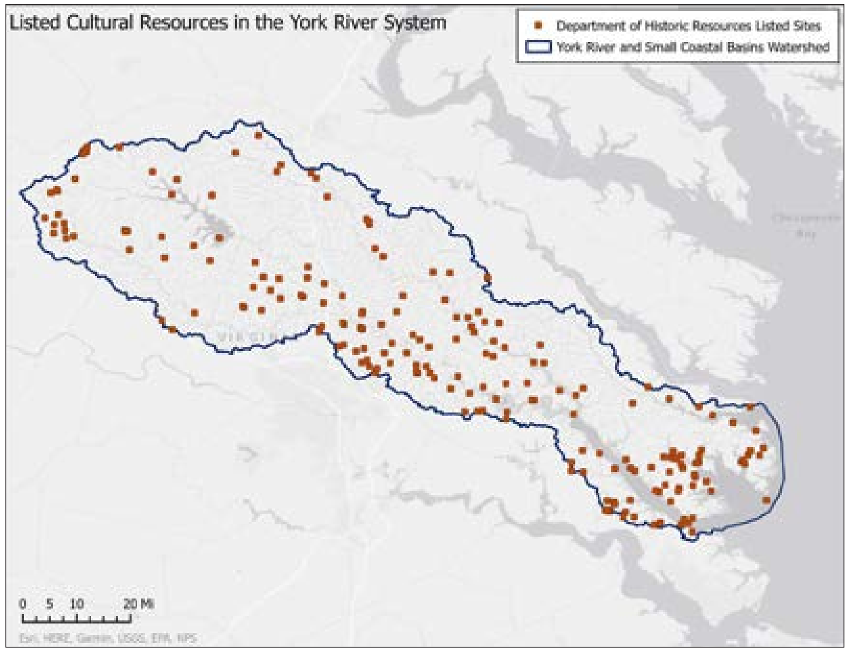


Figure 33. Listed Historic Resources in the York Watershed System. The term "listed" applies to historic resources, or historically and culturally significant properties, that have received one or more of the following designations: Virginia Landmarks Register, National Register of Historic Places, and/or National Historic Landmark. *Source: Virginia Department of Historic Resources.*

Case Study | Machicomoco

The Catlett Islands, in the York River, face an imminent threat from rising sea levels and weather events, endangering natural and cultural resources. The islands hold evidence of thousands of years of Indigenous settlement, European settlement since the 17th century, and enslaved and free African Americans from the 18th through mid-20th century. The sites are at risk of destruction, and continued research and planned preservation are necessary to understand the ongoing threats and learn more about the resources. The Fairfield Foundation, a nonprofit promoting archaeology, preservation, and education of the Middle Peninsula, is working with VIMS toward this goal.

From 2019-2022, in collaboration with the Chesapeake Bay National Estuarine Research Reserve in Virginia (CBNERR-VA) of VIMS, with support of the Virginia Department of Historic Resources (DHR) Threatened Sites Program, the Fairfield Foundation conducted an initial archaeological survey and limited testing at the Catlett Islands. Since 2019, the foundation has also conducted historical, archaeological, and preservation research on the late 18th-century Timberneck House which is located within Machicomoco State Park and looks out on the islands. The islands connect to Timberneck by the Catlett family, who built and lived in the house for more than 200 years and farmed on the islands.

The recovery of hundreds of domestic artifacts, including broken porcelain doll pieces and carpenter pencil lead, as well as architectural material such as window glass and a fallen windmill, humanized the people on the island. These objects reveal past residents' everyday use of these sites, confronting how we look at and interpret them to the public. These islands are not publicly accessible but exhibits in the state park and the Timberneck House can augment lectures and hands-on experiences with items to increase public engagement, while continued fieldwork can help retrieve additional information before the sites disappear entirely.

The Timberneck House and the Catlett Islands. *Credit: Fairfield Foundation.*

Archaeologists excavate a test unit on the Catlett Islands. *Credit: Fairfield Foundation.*

Op

Today, regional livelihoods remain reliant on natural and cultural resources, whether on account of harvest, management, recreation and/or tourism. Moreover, we rely on these resources to inspire and bring us joy; to provide a place for rejuvenation and relaxation; to define community pride and identity.

Our reliance on these resources is predicated on a recognition of the delicate balance they help keep, an awareness of our responsibility to preserve this balance, and their sustainable management in the face of a changing socioecological system (see page 36). Through purposeful planning with these elements in place, we can ensure their continued enjoyment and celebration in the present and into the future.

Blue crab harvest in the York Watershed System. *Credit: M. Thayer.*

Charter fishing in the York Watershed System. *Credit: Consociate Media.*

Paddle on the Mattaponi with Mattaponi and Pamunkey Rivers Association. *Credit: CBNERR-VA.*

?!

The York River and Small Coastal Basin Roundtable has developed its Top 12 Best Business Practices for Watershed System Resilience; check the list out **here**.

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Perhaps among the most iconic regional resources is the Eastern Oyster, ***Crassostrea virginica***. Once depleted, Eastern Oyster populations throughout the Chesapeake Bay have rebounded in response to sustainable management practices. In the York Watershed System, a return to oyster harvest and aquaculture has been a boon for both private and public sectors, and one that every watershed resident, shellfish eater or not, can celebrate.

In 2021, oyster landings from public York River waters alone totaled 287,182 pounds, equivalent to a value of more than $2.5 million (Virginia Marine Resources Commission data). Reflecting an increase in York River public water landings since 2007, these numbers follow a trend echoed by landings in leased (aquacultured) waters.

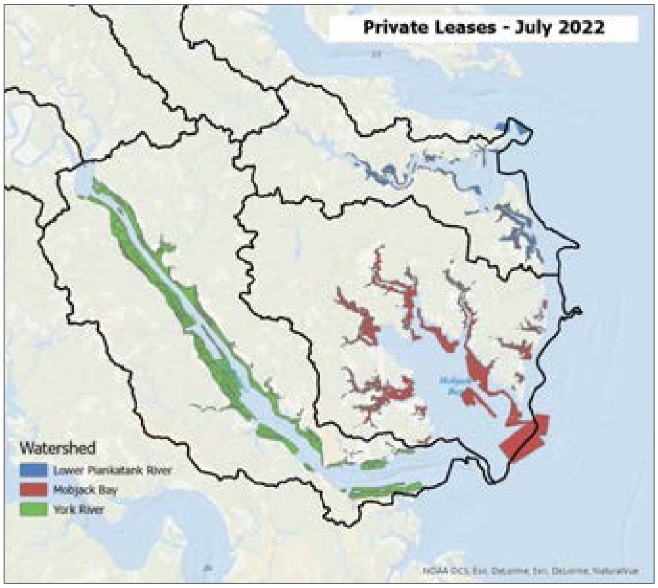

Figure 34. Permitted, private leases in the lower York Watershed System, July 2022. Data received from the Virginia Marine Resources Commission (VMRC), or downloaded from the **VMRC Chesapeake Bay Map**.

A waterman works on his oyster cages located along the York River. *Credit: Aileen Devlin | Virginia Sea Grant.*

Since 2010, the applications for private aquaculture leases in the York Watershed System have been on the rise, namely in the Mobjack Bay. By July of 2022, resulting permits translated to 1,096 private leases holding 36,675 acres in the York Watershed System (*Figure 34*).

Oysters raised for human consumption contribute to regional culture and identity, and provide additional benefits to the ecosystem through habitat and improved water quality. To leverage the complete suite of benefits they provide to us and our environment, oysters are also raised for non-consumptive uses; specifically, to help restore lost habitats, improve water quality and lessen shoreline erosion. Recognizing that oysters play an important role in maintaining water quality and providing essential habitat for tidewater species, oyster reef restoration efforts in the York Watershed System are well underway (*Figure 35*). As of June 2022, 486 acres of oyster restoration have been completed within the York Watershed System, while 423 acres for oyster restoration efforts remain proposed. Among and in addition to these acres, Virginia Oyster Stock Assessment and Replenishment Archive (VOSARA) oyster reefs are managed with a primary focus on restoring oyster grounds for harvest.

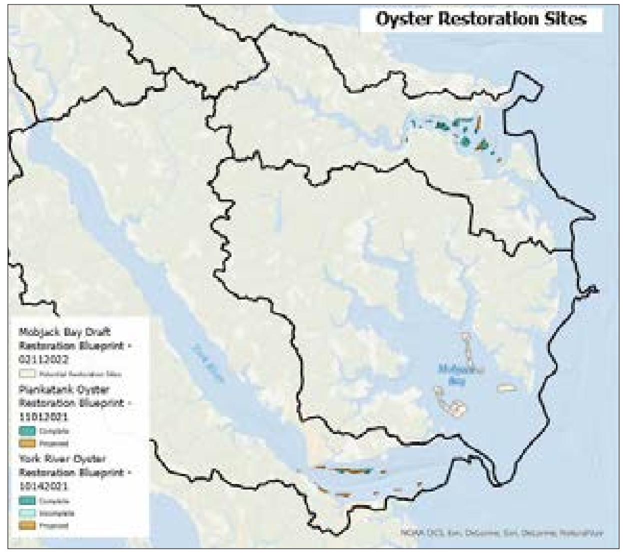

Figure 35. Oyster restoration sites within the York Watershed System. *Credit: CCRM.*

Whether you're planning to grow oysters for your own consumption, donation to oyster reefs or for some other reason, your efforts can help improve water quality and biodiversity along Virginia's coast. Learn more about oyster gardening with this Coastal Zone Management Program resource.

Partners in York River oyster restoration celebrate goal achievement in the lower York River subwatershed with additional oyster shells, 2024. *Credit: NOAA Chesapeake Bay Office.*

The end result of the oyster's resurgence through the combination of aquaculture and restoration efforts in the York Watershed System is a win win-win+ situation: our waters win with increased oyster filtration; tidewater species win with increased habitat; coastal communities win through increased storm surge protection that the reefs offer, through increased opportunities in oyster harvesting and aquaculture, and through increased access to tasty local fare proudly raised in their backyard.

"Aquaculture is putting a new spin on coastal Virginia's traditional ways to make a living on water; and the bonus is that there's a net positive effect. Think: habitat, think: jobs, think: coastal culture."

- Bill Walton, Acuff Professor of Marine Science and Shellfish Aquaculture Program Coordinator

Buy and enjoy local, Virginian oysters and support the hardworking people that harvest them. More local oysters on your plate mean more oysters in our local waters.

Eating oysters? Don't chuck that shuck! Restoration efforts can use your help! Oyster shell recycling through the Virginia Oyster Shell Recycling Program (VOSRP), a public-private and non-profit collaborative effort, "takes shells destined for the trash and returns them to restoration areas in the Piankatank River." Serving central and eastern Virginia, this organization relies on the strength of volunteers, restaurants, and consumers alike. Look for shell recycling drop-off locations at the VOSRP link above.

Oysters on scene at Crown Pointe Marina in Hayes, Va. *Credit: Aileen Devlin | Virginia Sea Grant.*

Volunteers depositing oyster shells into the Piankatank. *Credit: Aileen Devlin | Virginia Sea Grant.*

Seagrasses, like oyster reefs, provide critical habitat for key York Watershed System species and protect coastal banks from erosion. Two predominant species of this submerged aquatic vegetation (SAV) populate the shorescape, or shoreline, within the system's tidewaters: eelgrass (*Zostera marina*) and widgeon grass (*Ruppia maritima*). In contrast to oysters, the presence of these seagrasses within the watershed system is on the decline – fraught with increasing water temperatures.

Figure 36 depicts the location and density of seagrass beds in 2020, while **Table 9** displays coverage in acres. While more acres of SAV are found in Mobjack than the remaining five subwatersheds, the Pamunkey subwatershed has nearly double the ratio of the densest coverage as compared with the next highest subwatershed, the Mattaponi.

York River seagrass is seen as dark patches from the surface. *Credit: CBNERR-VA.*

Figure 36. Seagrass bed location and density of coverage in the York Watershed System, 2020. *Data source: VIMS SAV Program*.

Table 9. Total area, in acres, of submerged aquatic vegetation coverage, by subwatershed. *Data source: VIMS SAV Program*.

Subwatershed	Total SAV area (acres)	Percentage of SAV area acres with 70 – 100% SAV density
Dragon Run	1.9	21.05
Mattaponi River	86	40.35
Mobjack Bay	4316.2	34.98
Pamunkey River	1052.3	76.77
Piankatank River	285.7	17.40
York River	1489.4	30.07
System coverage	**7231.5**	**39.41**

Case Study | *Ruppia* to the rescue?

Since the early 2000s, lower York River seagrasses, also known as submerged aquatic vegetation (SAV), have experienced periodic sharp declines in coverage (***Figure* 37**). Research in the York River has shown that these declines are associated with short-term heat events where water temperatures become too stressful for the dominant species, *Zostera marina* (eelgrass) (**Shields et al. 2019**). Eelgrass is a temperate species that grows near the southern limits of its distribution in the Chesapeake Bay, making it particularly susceptible to warming water temperatures (see **page 41**).

Ruppia maritima (widgeon grass), the other seagrass species that grows in York River tidewaters, has a higher optimum temperature for its growth. Accordingly, widgeon grass has been observed to temporarily replace eelgrass in some areas of eelgrass decline. This replacement has helped mitigate less productive, bare sediment habitat and may be critical in filling the roles of a productive eelgrass habitat. However, widgeon grass is an opportunistic species characterized by "boom or bust" cycles (**Orth et al. 2010**), thus the extent of its replacement of eelgrass in the long term is uncertain and a critical area of future research.

The extent of widgeon grass replacement is not well known and a critical area of future research with implications for shoreline and habitat resilience.

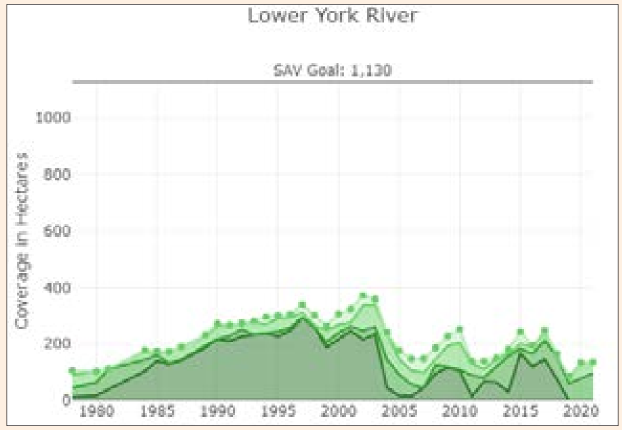

Figure 37. Submerged aquatic vegetation (SAV) coverage in the lower York River over time. Coverage based on aerial imagery. Green dots represent total mapped hectares per year. Shaded areas underneath indicate different density classes. The darkest green represents the densest class; the lightest green, the sparsest. Notably, the Chesapeake Bay Program, through its SAV Workgroup, has established a Bay-wide SAV restoration goal of 185,000 acres. Each segment has their own separate restoration targets that contribute to this regional target. The goal for the lower York River, as indicated in the figure, has been set at 1,130 acres. SAV coverage in the lower York remains far below this goal. *Credit*: ***VIMS SAV Monitoring & Restoration Program***

Seagrass monitoring in the York River. *Credit: CBNERR-VA.*

> *"With each news story about the environment gloomier than the last, conservation can feel like a losing battle, but nature is resilient! The York River continues to support astounding ecological diversity despite significant headwinds in the form of pollution and poor water quality. A united push for cleaner water and the re-introduction of native submerged aquatic vegetation can restore and strengthen vulnerable populations of waterfowl, fish, and myriad other river creatures. We just have to give it the chance."* - *Teddy Mitchell, York Watershed System resident*

Fish Habitat is Essential!

Fish spawn, breed, feed or grow to maturity in a variety of habitats (think: seagrasses, oyster reefs, marshes, as well as muddy or sandy bottoms). Protecting and restoring these habitats helps ensure sustainable commercial and recreational fisheries. In fact, these habitats are often essential to fish survival. In recognition of the vital role a habitat can afford our predominant fisheries, habitat areas may be federally designated as Essential Fish Habitat. This designation, mandated through the Magnuson-Stevens Fishery Conservation and Management Act, offers

Approximately 12 York River species have federally-designated Essential Fish Habitat. Collectively, their designated areas represent the majority of tidally-influenced waters in the York Watershed System.

> *"The crux of fisheries management goes back to habitat; if you don't have habitat you won't have any fish. ...And habitat's not just about the physical space; benthic communities, harmful algal blooms, nutrient loading - all facets of water quality really, factor in and support various fish species during one or more phases of their life history."*
>
> *- Dave O'Brien, NOAA*

Essential Fish Habitat areas vary with fish species and season, factoring in elements like lifestage, bottom-type, and water depth, though elements like recreational fishing impact currently remain out of the equation.

An angler catches flounder on a pier overlooking marsh habitat. *Credit: C. Gonzalez*.

While periodically updated to reflect changes in these elements, Essential Fish Habitat was last updated 20 years ago in the mid Atlantic. A contemporary assessment and related updates to Essential Fish Habitat are merited.

A **recent study** suggests marshes and living shorelines in the Middle Peninsula produce **$6.42 million in annual benefits** associated with recreational fishing, a value which is more than three times greater than that produced by hardened shorelines. For more on living shorelines, see **pages 22-24 and 25-26**.

Unlike stationary oysters and seagrass, or the habitat they provide, a lot of the life that the York Watershed System fosters is mobile!

As part of their life cycle, fish may move within a water body or migrate between multiple, sometimes moving between freshwater and saltwater. Many species in the York Watershed System move within the York River and its tributaries, as well as between the York River and the Chesapeake Bay.

The catch and take of fish, and other aquatic species, defines its fishery, which can be either commercial (for profit) or recreational (for pleasure and/or sustenance). A variety of fishery managers, at state, regional and federal levels, oversee the activity involved in York Watershed System fisheries and define their related limits in an effort to ensure sustainable fish harvest. Seasonal, size, and catch limits are among the science-based regulations these agencies define, each informed by a species life cycle and trends in its population and landings (or catch), as well as trends in habitat and water quality.

On the following pages devoted to ***Table 10***, we report on the most common York Watershed System commercial fisheries managed by the Virginia Marine Resources Commission and the Atlantic States Marine Fisheries Commission, which oversee the fisheries within state waters (waters lying within a three-mile boundary from shore). Included are figures related to white shrimp, a species with increasing commercial potential given its growing population in the System, likely associated with warming water trends. Further on, beginning on page 83, we highlight some of the freshwater, recreational fisheries overseen by the Virginia Department of Wildlife Resources.

The York River subwatershed has hosted approximately 128 species of bony fish since 1955.

A croaker is caught in the York River where it is both commercially and recreationally valued. *Credit: Anonymous Gloucester County angler*.

Recreational fishing data reflecting landings in either economic value or pounds, and specific to predominant York Watershed System species, is not collected and reported for use. Related data on catch per unit effort is collected and aggregated by agencies like Virginia's Department of Wildlife Resources (for freshwater and tidal species), as well as the Virginia Marine Resource Commission and NOAA, the National Ocean and Atmospheric Association (for tidal and saltwater species). However, recreational landings data specific to York Watershed System species is recognized as a data gap and priority need. The provision of landing data from waters System-wide is necessary to inform an improved understanding of recreational impact to both environment and economy, and will help in outreach efforts connected to, and targeting the enhancement of, fishable waters.

Notably, four reported species are experiencing increases in their population trends, while two (Summer Flounder and Weakfish), have declined in population since 1989. Croaker and Striped Bass are the only fish to exhibit a significant trend in landings, with reductions in total pounds landed since 2010.

Table 10. Population and landing trends for the most common York Watershed System commercial fisheries in addition to white shrimp, a species with increasing commercial potential. Green shading indicates significant increases, while red shading, significant decreases; gray shading reflects the lack of a significant trend.

Species name (common)	Scientific name	Native population range	Habitat preferences
Atlantic Croaker	Micropogonias undulatus	western Atlantic Coast from Massachusetts to Florida and throughout the Gulf of Mexico. also possibly from southern Brazil to Argentina	sandy or muddy substrates, often associated with SAV
Blue Crab	Callinectes sapidus	along the Atlantic Coast of the Americas from Nova Scotia to Argentina, including the Gulf of Mexico	range upstream to the tidal freshwater sections of the Mattaponi and Pamunkey rivers
Blue catfish	Ictalurus furcatus	native to the Mississippi, Missouri, Ohio, and Rio Grande river basins	freshwater and brackish waters; main channel of large rivers; established in the Mattaponi and Pamunkey rivers
Spot	Leiostomus xanthurus	Cape Cod to Bay of Campeche, Mexico	adults are namely found in the lower York River; juveniles move upriver to lower salinity tidal creeks
Striped Bass	Morone saxatilis	East Coast from the St. Lawrence River in Canada to St. John's River in Florida, and in the Gulf of Mexico from Florida to Louisiana	anadramous; found in marine, estuarine or riverine habitats, depending on season
Summer Flounder	Paralichthys dentatus	Atlantic Ocean from Nova Scotia to the east coast of Florida	prefer sandy habitats, though are also found near eel grass beds (esp. juveniles) or in marsh creeks
Weakfish (aka grey trout)	Cynoscion regalis	Nova Scotia, Canada to northern Florida, USA	sand or sand/mud bottoms in shallow waters
White Shrimp	Litopenaeus setiferus	Fire Island, New York, to St. Lucie Inlet on the Atlantic Coast of Florida	

** Excludes any confidential data, and years where there was no reported fishery.
+ Significantly declining landing trends (detailed in red) reflect poundage vs. dollar.

Table sources:

- Chesapeake Bay Program Field Guide
- USGS Nonindigenous Aquatic Species
- NOAA Fisheries Species directory
- NatureServe Explorer
- Fishbase
- Murdy, E.O. and J.A. Musick, 2013. Field guide to fishes of the Chesapeake Bay. JHU Press, 360 p. DOI / ISBN, 9781421407685.
- Hewitt et al., 2009
- Virginia Marine Resources Commission

The commercial landing value for 7 of the most common System species totaled more than **$64 million** between 2010-2021.

	Migration patterns relative to York Watershed System	Population trend in the York Watershed System for years as noted.	Commercial landing data in the York Watershed System, both in value and pounds from 2010 to 2021.**
	adults spawn offshore from July through February and move into the York River in late spring where they stay until Fall, migrating back offshore	(1989-2021) *can vary dramatically year to year (6,200 pounds to 14 million since 1950)	$5,212,881 and 5,614,514+
	mating happens in the shallow waters of Chesapeake Bay's tributaries; females migrate toward salty Bay waters to develop their brood; larvae develop offshore; further development into juvenilles takes place in SAV	(1989-2021)	$52,792,038 and 44,575,964
		(1989-2021)	$642,011 and 1,669,368
	seasonal migrations from estuarine and coastal waters to offshore spawning grounds in Winter; adults and juveniles are found in the York River from Spring until Fall when they migrate south to Cape Hatteras	(1989-2021) *fluctuates annually in response to environmental factors	$2,267,690 and 1,279,921
	year-round residents; spring spawning takes place in the freshwaters of the Pamunkey and Mattaponi; after spawning, adults depart the Bay and migrate north, returning in Fall	(1967-2021)	$3,275,676 and 1,088,121 lbs+
	adults spend winter months offshore on outer continental shelf; from Spring to Fall they're found in the lower York River	(1989-2021)	$26,217 and 8,016
	move into the York River in Spring and migrate to coastal waters in Fall	(1989-2021)	$31,083 and 20,954
	newly hatched shrimp travel to their estuarine nursery habitats in April and early May	(1991-2021)	No data

Striped Bass data:

- Buchanan et al., 2022

All other species data:

- Tuckey and Fabrizio, 2021

Fisheries management approaches are informed by a number of factors, most directly related to fish populations and their associated threats. In the York Watershed System, overfishing and habitat alteration are major threats to fish populations. Notably, habitat alteration includes changes in water quality (e.g. nutrients, sediments, contaminants, temperature), which have implications on reproduction and livability, as well as changes to riverine flow and structural habitat like wetlands, through water withdrawal, erosion, dredging, shoreline hardening, and damming.

Migratory fish like striped bass, American eels, American shad and river herring are especially vulnerable to damming and road stream crossings as their life history requires them to live and breed in completely separate habitats. Barriers, such as undersized culverts and dams, make the journey between these locations more difficult for the fish to travel and limit the accessible habitat available for spawning and breeding. Moreover, these obstacles can concentrate fish in one place, making them easy targets for predators.

Case Study | Boundless: Anadromous fish x Ashland Mill Dam

"The highest priority barrier removal right now for migratory fish in the York Watershed System was the Ashland Mill Dam on the South Anna. Among priority projects in the entire Chesapeake watershed, it ranked in the top 1%."

– Alan Weaver, Virginia Department of Wildlife Resources.

At the beginning of the modern fish passage era, which started in the late 1980's, a list of dams on the mainstems of major rivers was created for each Chesapeake Bay state. Ashland Mill Dam is now among the many dams that have been removed. Removal began in late September of 2024 and was completed in October of 2024.

Heavy machinery works to demolish and remove the 1916 Ashland Mill Dam making way for migratory and resident fish species. *Credit: Alan Weaver.*

When it sat atop the South Anna River just upstream of US Route 1, the 13 ft tall x 200 ft wide hydromechanical dam worked to provide power for a flour mill that is no longer in operation. Virginia's Department of Wildlife Resources (DWR) has monitored the river downstream of the dam for many years; all the major species targeted in fish passage restoration continue to be documented in the dam's downstream

Virginia Department of Wildlife Resources and Randolph Macon College sampling below Ashland Mill Dam. *Credit: Melinda Weaver.*

waters: American Shad, Hickory Shad, Alewife, Blueback Herring, American Eel, Striped Bass and Sea Lamprey.

Dam removal will significantly benefit the York Watershed System, specifically the health of the South Anna River and Pamunkey fish populations, by providing upstream access to highly important spawning and rearing habitat for the migratory fish that were obstructed by the dam. Several resident fish species, as well as the freshwater mussels that the fish serve (by transporting the mussels' larvae upstream) will also benefit. There are approximately 209 "Upstream Functional Network" miles above Ashland Mill Dam representing the total of all unobstructed miles on the South Anna and its accessible tributaries in the dam's upstream waters. Catadromous American Eel will now more easily access all of that habitat, and more than 100 of those miles can now be accessed by several anadromous species.

Like other dams in the York Watershed System, the Ashland Mill property is privately owned, complicating the provision of public funding for its removal. Davey Mitigation, along with Wetland Studies and Solutions (divisions of Davey Resources Group, Inc.), invested private funding to complete the long-desired ecological restoration in pursuit of mitigation credits. These credits can be sold to permittees to offset environmental impacts of future projects. The U.S. Army Corps of Engineers and Virginia's Department of Environmental Quality approved this mitigation banking instrument for the project after diligent review inclusive of input from an Interagency Review Team.

In preparation for removal, DWR teamed up with faculty and students from Randolph Macon College to conduct additional pre-removal sampling in the South Anna during the spring of 2024. Sampling was successful at documenting the presence of target species and upstream sampling was initiated in the summer to increase the baseline data set. Post-removal assessment is planned, and the researchers are looking forward to Spring 2025 when they expect to see target species making use of the recently reconnected habitat.

While Ashland Mill Dam represents the highest priority removal site, there are an estimated **350 dams** in the York Watershed System.

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The Nature Conservancy has identified 350 dams (*Figure 38*) in the York Watershed System and prioritized them according to information such as miles of stream that would be opened if the dam was removed, upstream habitat quality, and species present in the area. More than a third of the dams in the York Watershed System are ranked between Tier 1 and Tier 3, indicating they are high priority for removal or fish passage installation.

The Chesapeake Bay Fish Passage Prioritization Tool is a great resource for maps of dams in the York Watershed System. This tool uses ecological and physical metrics to rank dams in order of priority for removal or fish passage installation. Various scenarios allow users to prioritize for different fish passage solutions. Notably, the tool does not currently integrate social feasibility metrics such as economic and ownership considerations.

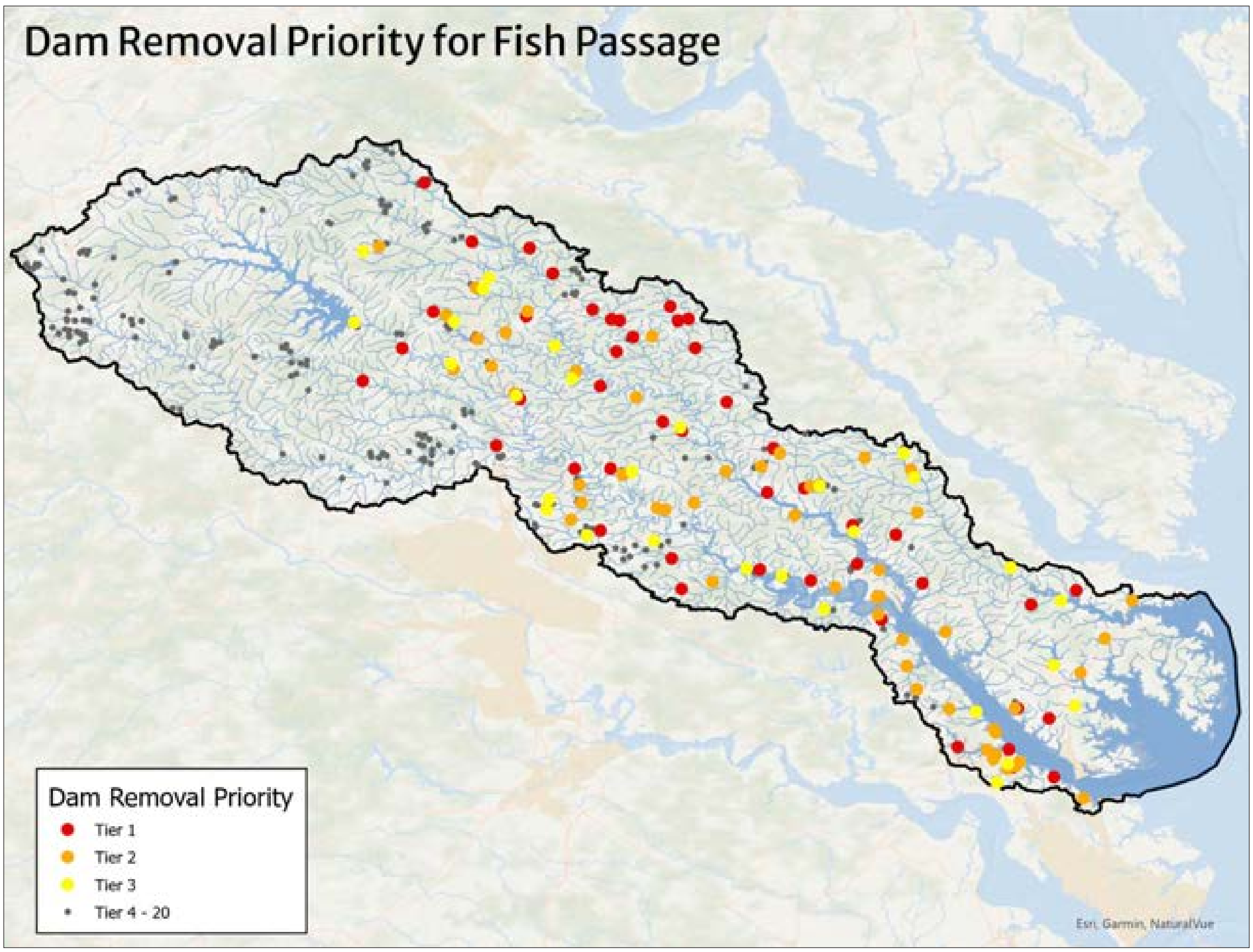

Figure 38. Dam removal for fish passage prioritization in the York Watershed System. *Data source: Chesapeake Bay Fish Passage Prioritization Tool*.

Road stream crossings are an additional concern to fish passage though little is known of them in the York Watershed System. Only six of the nearly 7,040 crossings within the System have been assessed. More research on the topic is merited.

Invasive species are intentionally or accidentally introduced by human activity into a region in which they did not evolve and cause harm to natural resources, economic activity, or humans. Invasive species differ from **naturalized species**, which are also introduced, but unlike invasives, have harmonized with the native ecosystem and do not cause it harm.

In addition to dams, invasive species can contribute to destructive habitat alteration, threatening fisheries populations and native habitats, along with the inherent natural balance between native aquatic and terrestrial wildlife populations.

Within the York Watershed System, *Phragmites australis*, an invasive reedgrass, has altered marsh ecosystems through shifts in native marsh vegetation species. Marshes are a critical regional resource for a variety of reasons, including but not limited to their essential role as fish habitat (spawning, breeding, feeding and growing!), their ability to filter nutrients and sediments, their ability to temper wave energy and erosion, and their capacity for storing carbon (for more on System marshes, visit page 7). Shifts from native marsh vegetation to *Phragmites* have altered these marsh roles, in addition to changing food source dynamics and increasing fire potential.

Case Study | *Phragmites* on the Rise*

The introduction and expansion of the invasive reedgrass, *Phragmites australis*, throughout the York Watershed System has been one cause of significant change in tidal marsh plant composition. Whereas non-native reedgrass community types were absent or in trace amounts in a 1970s historic survey, more recent wetland surveys indicate that *Phragmites* is distributed throughout the York Watershed System. In fact, it's becoming dominant within some marshes (a dominant species within 70 acres of the System's tidal marshes) and is present in more than 10,000 acres of tidal marsh. These trends in *Phragmites* expansion occurred in all surveyed subwatersheds included in this report (see *Table 11*).

Table 11. Presence of the invasive reedgrass, *Phragmites australis* in the York Watershed System subwatersheds as of 2022. CCRM 2022. Virginia Tidal Marsh Inventory, Virginia Institute of Marine Science. Gloucester Point, Virginia.

	Phragmites australis coverage(acres)			
Subwatershed	**Dominant (>=50%)**	**Present (<50%)**	**Not Observed (0%)**	**Undetermined (not recorded)**
Dragon Run	-	-	-	78.0
Mattaponi River	2.8	1,928.6	1,430.4	1,421.0
Mobjack Bay	23.9	1,053.5	-	5,377.6
Pamunkey River	13.5	3,983.0	1,079.1	2,101.6
Piankatank River	13.0	385.0	-	843.1
York River	16.9	4,123.9	446.9	2,752.5
TOTALS	**70.2**	**11,474.0**	**2,956.4**	**12,573.8**

*Sources: Moore and Silberhorn (1976); Priest et al. (1987); Silberhorn and Zacherle (1987); Moore and Silberhorn (1980); Silberhorn (1974); Priest and Silberhorn (1981)

Don't invite the invader in! Avoid disturbing or clearing land along shores. Doing so invites *Phragmites* to invade and establish, making it extremely challenging to manage.

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The invasive reedgrass *Phragmites australis* along York Watershed System shores. *Credit: CBNERR-VA.*

Established invasives, like the plant species *Phragmites australis*, threaten a variety of native species populations and biodiversity on the whole. Emerging invasives are of concern for similar reasons. For example, Nutria, rodents native to South America, are a destructive invasive species capable of altering, if not converting, valuable marsh habitat.

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Virginia's Department of Wildlife Resources (DWR) has taken a proactive approach to nutria in the York Watershed System. By regularly monitoring for the presence of nutria in the neighboring Chickahominy watershed, and taking action on nutria sightings within our System itself, DWR works to prevent the establishment of nutria and avoid their potential impacts.

See something, say something! Report any nutria you see here. If possible, try to get a photograph of the animal before sending in the report.

A sign along the York River encourages nutria spotters to report their sightings. *Credit: Abril Hunter.*


Left and right photos: Two-horned trapa in Virginian waters. *Credit: Kevin Heffernan.*

Of increasing concern in the York Watershed System is Two-horned trapa (*Trapa bispinosa*), a new aquatic invasive plant that is spreading rapidly across ponds and other waterbodies in northern Virginia. A cousin of the infamous European water chestnut that once choked the Potomac River, Two-horned trapa infests freshwater ponds, lakes, and slow-moving waterways, forming mats that shade out native vegetation and making waterways hard to navigate. Two-horned trapa has recently been documented within the System in Orange County. Early detection and eradication will be critical to controlling continued spread throughout the System.

On occasion, an invasive's negative impact on populations and habitat can be accompanied by ancillary benefits. Managing these threats in light of any benefits is a nuanced challenge for resource managers.

Help map and track invasive species! Online mapping tools and smartphone apps for reporting invasive species info can be found on the Virginia Invasive Species website here.

Visit the Trapa bispinosa Dashboard App for information on confirmed sites with Two-horned trapa and information on identified waterbodies within danger zones.

More information on invasive plant species occurring within the York Watershed System can be found on the Virginia Department of Conservation and Recreation's Natural Heritage portal dedicated to Invasive Plant Species of Virginia.

Additional information about invasive species, including links to the 2018 Virginia Invasive Species Management Plan currently in revision, can be found on the Commonwealth's Virginia Invasive Species website.

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Case Study | The Blue Catfish Balance*

Blue catfish (*Ictalurus furcatus*) are a somewhat complicated species within the Chesapeake Bay Watershed. Native to the Mississippi, Missouri, Ohio, and Rio Grande river basins, Blue catfish were introduced to the Chesapeake Bay Watershed in the 1970's. Since then, they have established populations in various Chesapeake Bay tributaries, including the York River. While in general they are a freshwater fish, they have a tolerance for brackish waters that bolsters their potential for range expansion. Deep, off-channel holes or river bends in mainstems and tributaries provide their ideal habitat.

Blue catfish are a valuable fish to the commercial and recreational fishing industries. Interest in this species commercially has increased within the last two decades. Catfish serve different purposes, including being a tasty and nutritious food source. As an expanding fishery, from 2010-2021 commercial fishermen collected 1,669,368 pounds of Blue catfish and generated $642,011 (see **pages 67-68**). Likewise, Blue catfish are a popular recreational species sought by anglers and have become established as a trophy fish. In Virginia, they are one of the most popular recreational fisheries in the state.

Sampling blue catfish. *Credit: Joe Schmitt.*

George Trice is one of several commercial fishers licensed to catch blue catfish through low-frequency electrofishing. This method delivers a nonlethal stun to catfish and does not affect protected species in Virginia waters. *Credit: Aileen Devlin | Virginia Sea Grant*

At the same time, Blue catfish pose a potential threat to native species within the York River. Studies have shown that the growth rates (in size) of Blue catfish are higher in the York River than any other tributary in the Chesapeake Bay. Their ranges have expanded and there is a growing concern about their effects on native species. Blue catfish can potentially outcompete native fish species as well as directly affect native species through predation. As generalist predators, Blue catfish feed on what is available to them, which can include Blue crabs, Shad, and River herring, among other native species. Moreover, they are able to tolerate higher salinity levels and produce large quantities of offspring during their spawning season, making their impact widespread.

Fisheries managers are faced with the difficult task of balancing native fish populations and the needs of commercial and recreational anglers. The **Invasive Catfish Workgroup (I.C.W)** was established to address concerns about potential negative effects of invasive Blue catfish, while ensuring that different stakeholders (commercial/recreational fishermen) still had a voice in management decisions. The I.C.W consists of state/federal managers, academics, recreational and commercial anglers, and other members of the public.

Blue catfish presence in the Chesapeake Bay are a challenge as they serve as both a valuable commercial/recreational fish, but also a potential threat to native biodiversity. However, as a well established population in the large Bay system, eradication is impossible. Focus on population reduction through increased fishing may represent the most effective means of management moving forward.

It is important that studies be conducted to better understand the effects and reach of invasive Blue catfish within the York River and the Chesapeake Bay Watershed. Likewise, it is important to continue to develop methods of reducing numbers of Blue catfish while allowing for a recreational and commercial fishery to remain. By working with a variety of stakeholders in groups like the I.C.W, we can find common ground and develop mutually beneficial strategies to manage the spread of these invasive fish.

Lessons learned in this Blue catfish balance may help inform the management of other invasives, like the Northern Snakehead, *Channa argus*.

Sarah Huber of VIMS' Nunnally Icthyology Collection demonstrates the snake-like patterned head on the invasive Northern Snakehead (*right*), a characteristic distinguishing it from the native Bowfin (*left*). *Credit: CBNERR-VA.*

***Sources:** Blue Catfish, NOAA Fisheries; Blue Catfish, Chesapeake Bay Program; Connelly 2001; Nepal and Fabrizio 2019; Blue Catfish: Invasive and Delicious; Fabrizio et al. 2020; Schmitt et al. 2018; The Invasive Catfish Workgroup (I.C.W).

Presence of the invasive Northern Snakehead has been confirmed in the Pamunkey River, though as of this report's printing, not yet in the Mattaponi River. Further study of these two river systems and the impact of the snakehead's presence/absence in respective waters is merited.

Know the difference. The invasive Northern Snakehead has multiple look-alikes, including native Bowfin, American Eel and Sea Lamprey. Learn to distinguish them from one another by checking out this Virginia Department of Wildlife Resources **Snakehead Identification site**. The Department asks that all snakeheads be killed if possible. More snakeheads and reporting them **here**.

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Resource managers in Virginia consider a suite of threats to System species and habitats when identifying native or naturalized species (see page 72 for definitions) as Species of Greatest Conservation Need (SGCN). Species classified as SGCN have low and declining populations and are threatened by invasive species, land development, habitat loss and degradation, or nonpoint source pollution (pages 48-49), among other factors like disease and illegal harvest. All of these factors are interconnected and exacerbated by climate change. Designation as an SGCN species reflects conservation need and opportunity, and helps inform conservation actions (e.g. management, monitoring, acquisition) that can stabilize populations, avoid extinction, and preserve distribution.

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The illegal collection and transport of turtles from Virginia is currently one of the Commonwealth's highest priority law enforcement issues when it comes to wildlife. Turtles are not only a high commodity in the pet trade, but are also harvested for cultural purposes, like food and medicine. Of the 8 turtle SGCN species in the York Watershed System, 2 are designated as species of "Collection Concern," indicating illegal harvest has been documented: Northern Diamond-Backed Terrapin, and the Spotted Turtle.

Table 12. Species and habitats of conservation interest and concern within the York Watershed System and its subwatersheds. *Data sources: *Virginia Department of Wildlife Resources and **Virginia Department of Conservation and Recreation's Natural Heritage Program.*

Conservation designation	Subwatershed						Total unique within York Watershed System
	Dragon Run	Mattaponi River	Mobjack Bay	Pamunkey River	Piankatank River	York River	
SGCN*	15	57	31	73	22	37	109
Rare species**	8	61	11	23	6	20	98
Significant Natural Communities (Aquatic)**	8 (3)	25 (5)	2	28 (7)	3 (2)	12	54(15)

- Virginia's 2015 Wildlife Action Plan addresses threats to species with recommended conservation actions in local summaries. Dig into this plan to learn what conservation actions in your area may help keep SGCN from becoming endangered. An updated Wildlife Action Plan is anticipated in 2025.
- Visit the Virginia Fish and Wildlife Information Service (VaFWIS) of the Virginia Department of Wildlife Resources (DWR) for information on York Watershed System species. Discover what conservation designations they have received, and what conservation opportunities may be afforded them.

Development of a guide for the York Watershed System's rare and threatened species is needed to help in outreach efforts. With increased awareness, residents and visitors alike can help turn the tide for these species of concern.

Examples of rare species documented in the York Watershed System (*Top left to right*): King rail (*Rallus elegans*), *credit: Tim Stamps;* Barking treefrog (*Hyla gratiosa*), *credit: Irv Wilson;* Sensitive joint-vetch (*Aeschynomene virginica*), *credit: Zach Bradford;* and Northeastern beach tiger beetle (*Habrosceliomorpha dorsalis dorsalis*), *credit: Steve Roble.* An example of a significant natural community (Bottom): Tidal Freshwater Marsh (*Wild Rice – Mixed Forbs Type*), *credit: Gary Fleming.*

Among, and in addition to the System's SGCN, exist **rare species**. The Commonwealth identifies species as rare to help prioritize monitoring and protection efforts. Rare species are not necessarily threatened or endangered, though their designation helps prioritize SGCN classifications. As with SGCN, rare species association does not offer additional legal protection, but helps inform conservation actions.

Among the **98 rare species** that have been documented in the York Watershed System, **28 are rare animals** and **70 are rare plants**. *Source: Virginia Department of Conservation and Recreation's Natural Heritage Program.*

Habitats, like species, can also be identified as rare. Rare habitats exhibiting key characteristics (e.g. size, condition, landscape context) and meritting inventory and tracking, are recognized by the Commonwealth as **significant natural communities**. Natural communities are habitats defined by a suite of features (e.g., vegetation, fauna, landforms) demonstrating interconnectedness in a given place. Natural communities repeat across a landscape and serve as important conservation targets. By identifying and protecting examples of all natural community types in Virginia, not just the rare ones, the majority of our native plant and animal species, and the ecological processes they depend on, can be conserved.

Discover more information on the biodiversity of the York Watershed System using the DCR Natural Heritage Data Explorer. Use the Species/Communities Search tool to generate lists of rare species that occur in your watershed, and visit the Map tool to view a suite of biodiversity and conservation information layers.

Though threatened in a variety of ways, habitat loss and degradation are the greatest threats to the conservation of our rare and threatened species. Within the York Watershed System, these threats are on the rise as our population increases and development is traded for habitat. The most meaningful actions we can take to combat these threats and preserve biodiversity are through habitat protection on land and in water.

Support your local land conservancy. Protected areas help ensure habitat is preserved for the species that depend on it. Land conservancies operating in the York Watershed System help secure habitat for rare, threatened, and endangered species through tools like protected areas and conservation easements. Search for a land conservancy working in your area, at this Virginia Department of Conservation and Recreation website.

Figure 39 demonstrates areas we have protected within the York Watershed System, and potential areas for future conservation prioritized based on their ecological value. Many of the latter are located in the Dragon Run subwatershed.

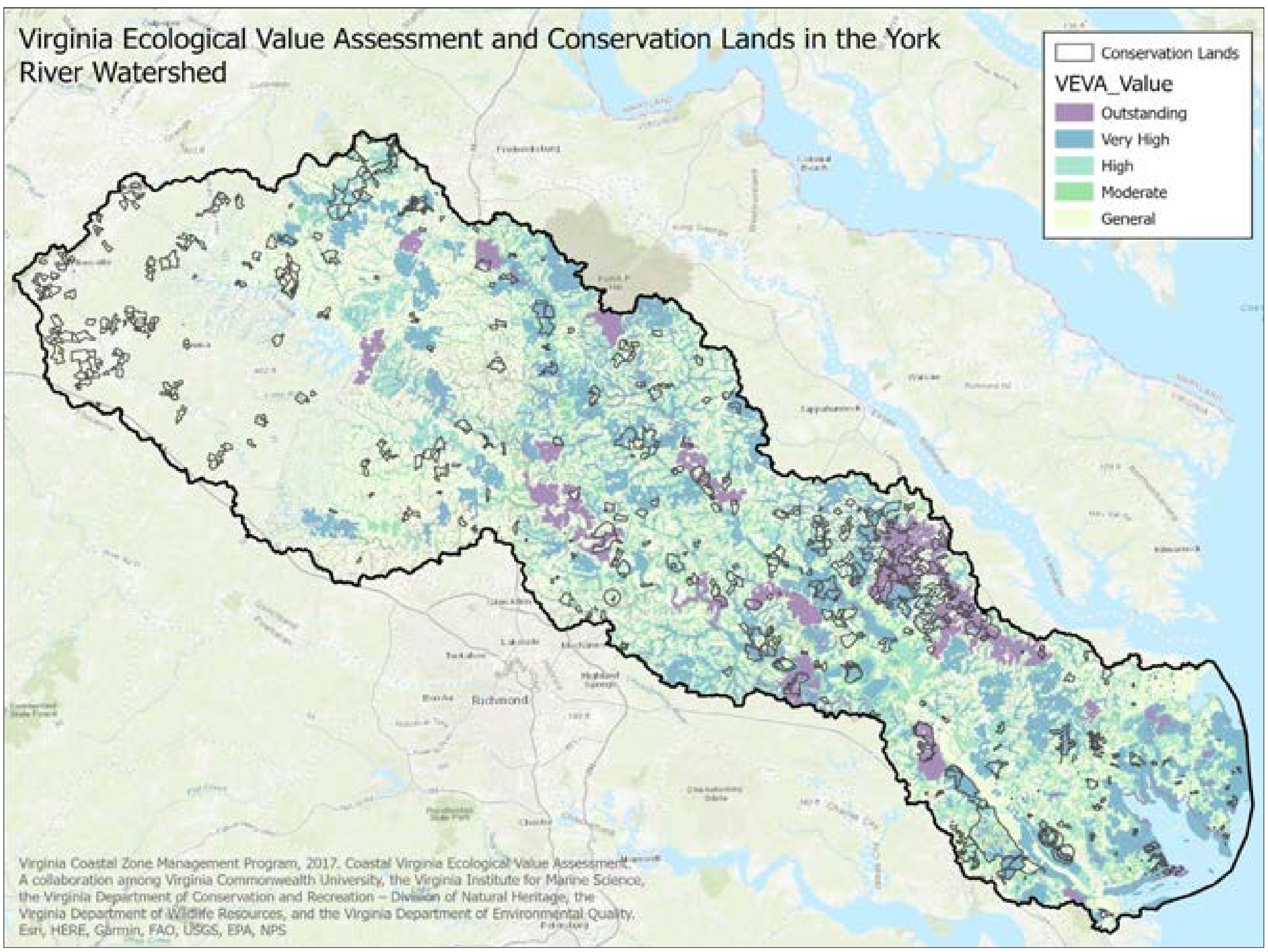

Figure 39. Boundaries indicating Conservation Lands within the York Watershed System (2023) are overlaid on lands prioritized for their ecological value through the Virginia Ecological Value Assessment (VEVA) process (2012). Conservation Lands include lands serving a variety of conservation roles (e.g. protection from development in perpetuity, provision of public access to outdoor recreation). Conservation values guide the management of these lands. *Source: VA Department of Environmental Quality*, downloaded 6/28/23.

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Protected areas throughout the York Watershed System exist on land and in water. Each offers varying degrees of protection for habitat and species, in addition to cultural resources. That said, protection is not the only purpose of these areas, many of which afford opportunities for activity such as research and recreation.

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The York Watershed System is host to approximately **350 discrete, protected areas*** administered by private, non-profit and public sectors across all levels of government. Federally protected areas include **Colonial National Historic Park**, **Captain John Smith Chesapeake National Historic Trail** and **Werowocomoco**, which is stewarded by the National Park Service in coordination with Tribal Nations who have historic connections to the site. State designated protected areas include six state wildlife management areas **Guinea Marsh** (**Mattaponi**, **Mattaponi Bluffs**, **Oakley Forest**, **Robert W. Duncan** and **Ware Creek**), three state parks (**Lake Anna**, **Machicomoco**, **York River**), three natural area preserves (**Bethel Beach**, **Cumberland Marsh**, **New Point Comfort)** and three state forests (**Dragon Run**, **Sandy Point**, **Zoar**). **Chesapeake Bay National Estuarine Research Reserve** in Virginia is unique in its oversight, with both federal and state management ties.

*Excluding conservation easements.

In fact, many of the System's protected areas offer public access to System waters, allowing for fishing, boating, kayaking and other outdoor recreation to coexist with resource protection.

Blazes help hikers navigate York Watershed System trails. *Credit: C. Gonzalez.*

Boat slips at Machicomoco State Park. *Credit: CBNERR-VA.*

Approximately **68 public access sites** in the York Watershed System provide residents and visitors traveling by land with access to water for outdoor-based recreation.

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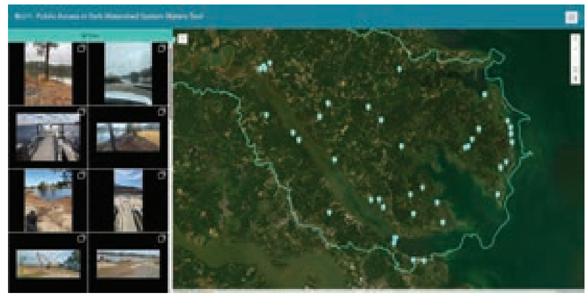
Determining permissible access to any water body is one facet of responsible recreation.

Know Where to Go! With nearly 70 sites in the York Watershed System that provide land-based access to outdoor, water recreation (think: fishing, boating, swimming), the options are endless! Learn where these sites are located and what each has to offer using this story map.



Click above for link to story map detailing the System's water-based recreation sites.

Responsible recreation acknowledges the shared nature of nature. Recreating in protected areas requires that we share space with protected resources, and share access to those resources with other community members. Recreating responsibly could mean:

- knowing the regulations associated with a space or activity before you enjoy it,
- following any guidelines on protection that land/water managers have established,
- limiting your carbon footprint in travels to and within an area,
- purchasing environmentally friendly options for activity enjoyment, and/or
- leaving no trace on your visit!

Enthusiasts jumping into the Mattaponi. *Credit: MPRA.*

Accompanying the benefits of recreation associated with protection, are benefits to the economy.

In the Tidewaters, the Middle Peninsula Chesapeake Bay Public Access Authority, through its Virginia's Coastal Wilds initiative, helps answer and research issues of public access while promoting associated economic benefits. The initiative was established in recognition of shorelines as high priority natural areas and the need to provide access sites for all types of recreational activities toward the benefit of the economy and the citizens of the Commonwealth.

The total economic value of recreation along the York, Pamunkey and Mattaponi rivers in 2022 was estimated to be **$15.5 million**. *Source: Gonyo et al. 2024*.

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Protecting and restoring vulnerable habitat in the York Watershed System is at the root of initiatives by the National Oceanic and Atmospheric Administration and the Department of Defense, which have respectively established a Habitat Focus Area (*Figure 40*) and Sentinel Landscapes (*Figure 41*) in the region. Each recognition supports improved resilience through holistic approaches rooted in habitat conservation and restoration, living shorelines included. Improved species stewardship, water quality and community resilience are a few anticipated outcomes of these ongoing efforts.

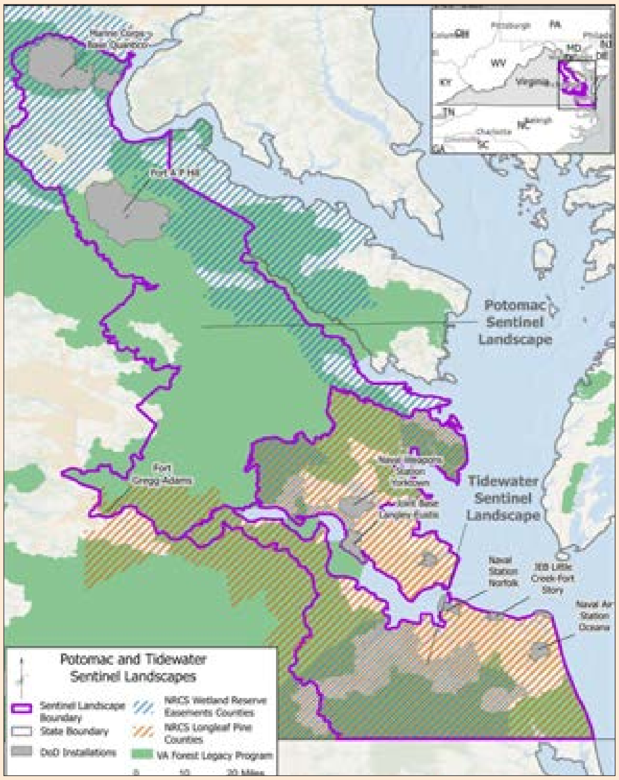

Figure 41. Potomac and Tidewater Sentinel Landscapes, established in 2023. Courtesy: Sentinel Landscape Partnership.

Figure 40. NOAA Habitat Focus Area, established 2022. Courtesy: NOAA.

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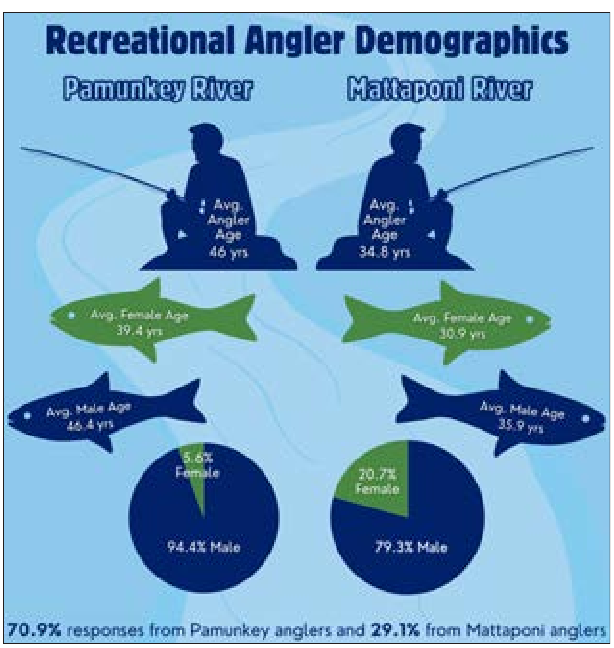
Further upstream in the System, diverging from the York River stem, public access sites along the Mattaponi and Pamunkey rivers, while fewer in number, continue to provide opportunities for recreational fishing. Recreational fisheries associated with these similar, albeit distinct, water bodies are managed by Virginia's Department of Wildlife Resources. Yearly surveys in these mid-System waters track approximately 65 species. From largemouth bass,crappie and bluegill, to white and yellow perch, pumpkinseed and shad, each of the species monitored represents a potential catch for the anglers that fish these waters.

Table 13 provides one indication of the abundance of fish in these waters with a metric focused on angling: catch per unit effort, or CPUE. The CPUE data detailed was provided by anglers during interviews wherein they described how long they fished, and the amount of fish they caught in that time. The greater the CPUE, the greater the catch to effort ratio. CPUE can vary given a variety of variables (e.g. gear, water and weather conditions, technique, etc.) and is thus not a strict measure of abundance.

Month	Pamunkey River			Mattaponi River			Total anglers actively surveyed in both rivers
	Anglers	Angler effort hours (average)	Angler CPUE (average)	Anglers	Angler effort hours (average)	Angler CPUE (average)	
Apr	138	6.30	0.83	76	4.66	0.46	214
May	94	6.45	0.69	50	2.90	0.56	144
Jun	188	7.70	0.72	58	4.32	0.47	246
Total	**420**	**6.96**	**0.74**	**184**	**4.06**	**0.49**	**604**

Table 13. Average recreational angler effort (in average hours spent angling) and catch per unit of effort in the Pamunkey and Mattaponi rivers per VA Department of Wildlife Resources (DWR) 2017 Creel Survey.



Who are the anglers putting in this effort? Check out the infographic for a detailed look!

In 2023, recreational fishing permits enabled approximately 8,300 people to fish in saltwater; 23,520 people to fish in freshwater; and 11,230 people to fish in both types of waters within the York Watershed System (Virginia Department of Wildlife Resources).

Toward the top of the York Watershed System, Lake Anna is the undeniable focal point for public access and water-based outdoor recreation. Distinguished by its diverse freshwater fisheries community, this human-made watershed feature is accessible to the public via Lake Anna State Park and numerous marinas. The lake achieves its natural potential to produce fishing opportunities in part through a historied stocking program and regulations on catch.

Case Study | Stocking Lake Anna

A 9,600-acre impoundment owned by Dominion Energy, Inc. (Dominion), Lake Anna spans Louisa, Spotsylvania and Orange counties and serves as cooling water for the North Anna Nuclear Power Station.

1972	Fish stocking begins with introductions of Largemouth Bass, Bluegill, Redear Sunfish and Channel Catfish. Subsequent stockings of Redear Sunfish, Channel Catfish, Walleye, Striped Bass and Largemouth Bass (both Florida and northern subspecies) are made.
1980s	Threadfin Shad and Blueback Herring are successfully introduced.
1994	Sterile Grass Carp are stocked by Dominion into a heat treatment facility and begin appearing in Lake Anna shortly after the stocking. A combination of climatic conditions and foraging by the Grass Carp reduce, and finally eliminate, Hydrilla, an non-native aquatic weed. Alongside the Hydrilla, other submersed aquatic vegetation (SAV) was eliminated. While the Grass Carp introductions were originally intended to help curb rapidly establishing Hydrilla, SAV's positive impacts on the lake's ecosystem, including those contributing to the Largemouth Bass population, diminish. It takes years for the Grass Carp population to decline through natural mortality, and for small amounts of SAV to reemerge.
2007	Walleye stocking is discontinued due to state agency reprioritization and low returns on catch.
2013	Saugeye (a cross between male Sauger and female Walleye) are stocked.
2014	Hybrid Striped Bass (a cross between male White Bass and female Striped Bass) are stocked.
2016	An additional, though small Grass Carp stocking occurs in response to property owner and user interests.
2019	After years of experimenting with stocking ratios of pure Striped Bass and its hybrid, a unique Lake Anna recipe is formulated to best fit the lake's habitat and productivity consisting of annual stockings of 10/acre of each, amounting to 192,000 fish annually.

Anglers with a catch on Lake Anna. *Credit: John Odenkirk.*

2020	Lake Anna becomes one of five Virginia reservoirs to receive experimental stockings of "F1" Largemouth Bass, a first generation cross between Northern Largemouth Bass and Florida Largemouth Bass. The goal of this decade-long experiment is to increase the maximum size of bass available to anglers.
Presently	Lake Anna is experiencing a rejuvenation that defies conventional wisdom regarding reservoir aging and typical reductions in productivity (e.g. fisheries biomass, fish growth rates, size structures) over time. This trend is likely driven, in part, by the relatively recent colonization of water willow, a native emergent wetland plant, and the resurgence of SAV. Largemouth Bass population metrics for abundance and size are at an all-time high, and other species such as Saugeye are displaying incredible survival and growth, diversifying the fishery.

Regulating for Recreation

To ensure that fish populations remain at sustainable levels for angling, stocking is accompanied by regulations on catch. Regulations for freshwater, saltwater and anadromous recreational species are overseen by Virginia's Department of Wildlife Resources (DWR) and the Virginia Marine Resources Commission (VMRC). Limits on the quantity caught and/or size of the catch may be determined in accordance with season and location. Based on monitoring data, like population counts, these regulations may change as a result of shifts in populations. Adhering to these regulations ensures continued recreational enjoyment for all in our shared waters.

Table 14. Regulations relating to stocked fish populations in Lake Anna (as of print, Virginia Department of Wildlife Resources, 2024).

Stocked Fishery	Lake Anna Regulations
Largemouth Bass	5 per day; no length limits
Gizzard Shad	No creel limits; no length limits
Threadfin Shad	No creel limits; no length limits
Striped Bass/Hybrid Striped Bass	4 per day in aggregate; 20" minimum
Black Crappie	25 per day; no length limits
White Perch	No creel limits; no length limits
Saugeye	5 per day; 18" minimum

A regulation sized catch on Lake Anna. *Credit: John Odenkirk.*

State regulations on all fish catch can be found **here**.

Healthy Resources: They take a village. To ensure that the York Watershed System continues to sustain healthy resources, all hands on deck are required! No matter your relationship to the watershed, as a resident, visitor, active steward and/or practitioner, there is a role you can play.

Op

You've headed to a public access site, caught your fish and checked the regulations... You're ready to prepare it, but is it safe to eat? The Virginia Department of Health is another important part of the village that's keeping our resources, and us, healthy and safe. Turn to their sites listed below for answers to questions on fish and shellfish consumption.

- Fish Consumption Advisory
- VDOH Emergency Shellfish Condemnation

Protecting our Resources Behind the Scenes. *Credit: CBNERR-VA.* The Virginia Department of Wildlife Resources (DWR), through its Conservation Police, enforces regulations related to both fishing and boating, educating recreation enthusiasts along the way. In concert with the Virginia Marine Resources Commission, an agency largely responsible for commercial fisheries, and their Marine Police, these uniformed officers collectively help protect and promote safe access and sustainable enjoyment in our System waters.

Case Study | Removing rubbish: VIMS' Crab Pot Removal program

Derelict (lost or abandoned) blue crab traps or pots, represent one of many forms of marine debris, or trash (for more on marine debris, see page 51). Commonly lost to storms, vessels, vandalism, equipment failure, and/or abandonment, these pots can continue to capture and kill valuable living resources long after they've served their purpose. Removal of marine debris, particularly derelict pots, can result in a natural resource and economic benefit if strategically conducted, which is what VIMS, in partnership with VMRC and Virginia watermen, did through its **Derelict Fishing Gear Removal Project**. Nearly 7,180 derelict pots were removed from York, Mobjack and Piankatank waters during this initiative, making up ~21% of the total traps removed from Virginian waters.

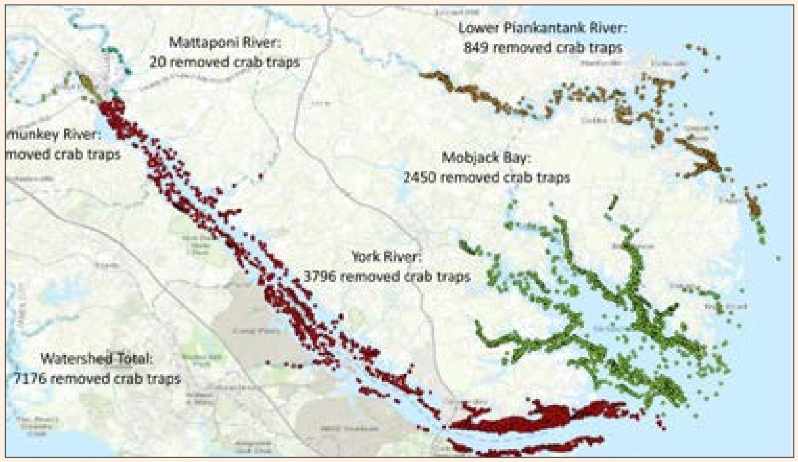


Figure 42. Crab pot removal in the lower York Watershed System, conducted primarily by commercial watermen during efforts between 2008 and 2014. A total of 7,176 crab pots were removed through this collaborative effort. *Data source: CCRM*

While the gear removal project initially engaged commercial fishers and resource managers, high school students and volunteer community scientists have since joined the effort through the Crab Trap App. Using this app, registered and trained community scientists locate derelict pots, document their location, and remove them from the water. Thanks to the participation of scientists, watermen, fisheries managers, students, and volunteers working together, Virginia's trap removal effort now covers a wide geographic area.

Derelict crab pot removal in York River waters. *Credit: CBNERR-VA.*

Sign up to volunteer on the Crab Trap App!

A few extra CALLS TO ACTION!

- **Know the regs.** Limits on catch, including size and quantity, are in place to ensure that populations can thrive and all can experience continued access to these valuable resources. These limits may change seasonally, and differ from place to place. Stay up to date on the latest rules in your choice waters by visiting the below sites:
  - Freshwater fishing regulations – overseen by Virginia's Department of Wildlife Resources
  - Saltwater fishing regulations – overseen by Virginia's Marine Resources Commission
  - Saltwater crabbing regulations – overseen by Virginia's Marine Resources Commission

  Not fishing? Regulations are also in place to help protect threatened and endangered species. Be a conscious collector by ensuring you know the rules! Visit this Virginia Department of Wildlife Resources guide on Collecting, Exhibiting, and Releasing Wildlife for more info.

- **Don't move fish around!** We know the allure is strong, but the potential damage may be severe. The implications can lead not only to environmental problems, but may also upset recreational and commercial uses. If you're returning a fish to a body of water, make sure it's the one it came from!

- **Share your photos of fish** on the RecFish app! The folks at Rec fish are working toward building a free app that will help anglers identify their fish, determine whether it's edible, and log their catch to help inform future fisheries science and management. ...But they need photos of fish. Submit yours, from all angles, pun intended, by visiting recfish.org.

A striped bass is landed in York Watershed System waters. *Credit: Bay Fly Fishing LLC.*

Angling in the York Watershed System. *Credit: C. Gonzalez.*

TAKE HOME POINTS

RECAP

1) We live in a watershed system comprising 3 basins and 6 subwatersheds.
2) Our System is largely natural in character. Its natural features continue to shape our culture and fuel our economy.
3) These natural features are in large part helping to mitigate pressures from increasing use and activity stemming from population growth. Many of these pressures are associated with development. However…
4) We cannot rely on the innate nature of our System, nor its natural assets, to alone continue to mitigate against increasing pressures like development and climate change, particularly as the natural assets themselves are at risk.

The bottom line?

5) System residents and visitors alike all have a responsibility to ensure that our waters remain fishable and swimmable while our population and activity within the System grows and expands. Positive change within our System is within our sphere of influence.

Learning about water quality on the York River with Chesapeake Bay National Estuarine Research Reserve in Virginia. *Credit: CBNERR-VA.*

On the preceding pages we hope you caught a glimpse at the story to date of our ever evolving York Watershed System. Admittedly, for all that's contained within this report, it represents the tiniest fraction of all that the York Watershed System is, was, and is becoming.

That said, it should reflect answers to some of the questions about our region that you've been after. In fact, the team behind this report developed its contents in response to informational needs that folks like yourself expressed. What you've just read took root in a System-wide needs assessment, complete with survey and interviews. It transitioned into the product of a multi-year collaboration between an interdisciplinary team, with invaluable input from external experts in practice and in place, to whom we are extremely grateful (see pages 99-100). Ultimately, **it's your report**; you called for it and the Roundtable responded. If and where we missed the mark, and you have lingering questions - do let us know!

What else about the York Watershed System would you like to learn? Let us know here!

RECOMMENDATIONS

For our part, digging through System related data has left us with more questions than answers. We've flagged some of our most pressing questions and gaps in information throughout the report, though acknowledge that our readers will have a slew of their own, and that new questions will surface as the System continues to evolve. **Addressing our collective questions and responding to the emerging ones, will necessitate the continued synthesis and delivery of accessible, System-related data and information, as well as continued collaboration, political will and funding.** To achieve each, the following are recommended:

Recommendations:

For the continued synthesis and delivery of accessible, System-related data and information:

- Regular and sustained financial support toward biennial report coordination and development.
- A common language for the System, and references to it in Commonwealth reports. See **Glossary for a Shared Understanding** on **page 95** for example terms.

For continued collaboration:

- Sustained support of the York River and Small Coastal Basin Roundtable through the Virginia Department of Environmental Quality's Chesapeake Bay Watershed Roundtable granting mechanism.

For political will and funding:

- Development of a forum for elected officials, akin to the Rappahannock River Basin Commission, for the discussion, coordination and action surrounding the protection, preservation, and – where needed – remediation of water quality, water quantity and environmental resources.

York River and Small Coastal Basin Roundtable members meet during an All-Hands event in King William County. *Credit: CBNERR-VA.*

UMBRELLA CALLS TO ACTION

"The task falls to each of us in the York watershed to play a role in shaping an imaginative and fresh public policy that ensures a productive, resilient watershed for generations to follow."

– State of the York 2000

The State of the York Watershed 2000 authors said it then, and we'll say it again. Each of us plays a role. Our system is shared, among us, and with nature – and because the changes to it and within it, impact us all, we all have a responsibility to steward it.

If you take away nothing else from this report, take this: Creating a positive ripple effect in the York Watershed System requires just a **DROP**:

Deepen your understanding of the issues. Explore the information and tools in this report and continue to ask meaningful questions of the topics they address. Through education and information exchange, we can make informed decisions and help others, including the elected officials we vote on, do the same.

Recreate responsibly in, and on, our shared waters. Enjoy our shared waters but remember they are just that: shared! We share them not only with each other, but with the natural world. As you celebrate all our System has to offer, aim to take only pictures and leave no trace.

Opt-in to conscious consumption. As a consumer, your purchases and habits have the power to impact the environment for better or worse. Moreover, the environment is responding to the impact of our collective purchases and uses, and has the potential to impact us (think: flooding). When you're making a purchase (be it for food or clothing, house goods or yard supplies, or even a house itself), or taking an action (like getting from point a to point b), consider the impact on the environment, and the environment's potential impact on you. Are there more sustainable alternatives available?

Participate in community efforts. Science and restoration are happening all around us and you can take part! Help monitor your favorite System species, or the water quality in your backyard; plant a tree, install a living shoreline, or make oyster reef balls. For ideas on how to plug into these efforts, connect with the York River and Small Coastal Basin Roundtable. Sign up as a Roundtable member to join water quality and conservation-minded partners in information sharing and collaboration on all things York Watershed System.

The State of the York is strong – but can be made stronger, and stay stronger for longer, together!

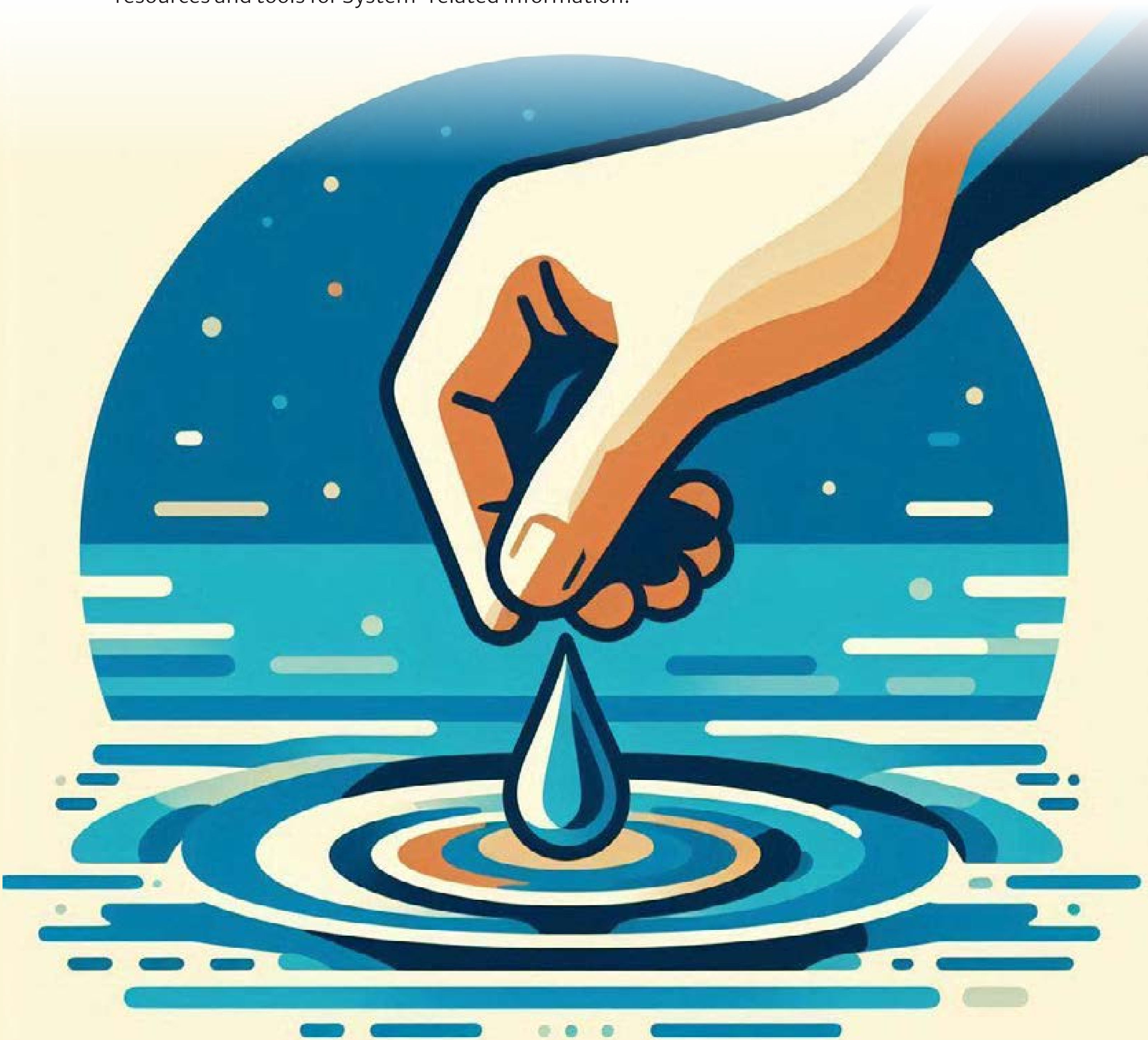
LEARN MORE HERE

Ready to **DROP** and become a York Watershed System steward? Deepen your understanding of the issues and learn about ways to participate in community efforts at State of the York headquarters.

At **State of the York HQ**, you'll find, you'll find links to: the full report, an accompanying storymap, and our One-Stop-Shop – a comprehensive inventory of resources and tools for System-related information.

State of the York HQ

York Watershed System One-Stop-Shop



GLOSSARY FOR A SHARED UNDERSTANDING

The following reflect terms used throughout the report that are known to have multiple meanings. Within the context of this report, and related York River and Small Coastal Basin Roundtable communications, we use these terms to represent the following:

- **Basin:** An area of land wherein water (surface and ground) drains to a common outlet. Used herein to describe the three main watersheds of the York Watershed System: Mobjack Bay, Piankatank and/or York River.
- **Best management practices:** Established actions designed to improve water quality through reduced nutrient and sediment loads.
- **Best practices:** Actions designed to ensure meaningful, efficient, and effective outcomes.
- **Coastal Plain:** A low-lying region east of the Atlantic Seaboard Fall Line and adjacent to the coast.
- **Development:** Growth characterized by the construction of a built environment, including houses,commercial and municipal buildings, in addition to the paving of roads and parking lots.
- **Piedmont:** A plateau region west of the Atlantic Seaboard Fall line characterized by low, roll-ing hills.
- **Subwatershed:** An area of land comprising a larger watershed and wherein water (surface and ground) drains to a common outlet. Used herein to describe the six subwatersheds in the York Watershed System: Dragon Run, Mattaponi River, Mobjack Bay, Pamunkey River, Piankatank River and York River.
- **tidewaters/Tidewaters (respectively):** low-lying areas in the Coastal Plain subject to tidally influenced waters, typically referring to areas wherein the tidal waters are saline; the region of the York Watershed System wherein those areas are located.
- **Watershed:** An area of land wherein water (surface and ground) drains to a common outlet. A watershed may be any number of sizes, and can contain multiples within.
- **York Watershed System (or System):** The collection of watersheds comprising of three main basins (Mobjack Bay, Piankatank River and York River), and six subwatersheds (Dragon Run, Mattaponi River, Mobjack Bay, Pamunkey River, Piankatank River and York River).

Gloucester Point Beach Park's fishing pier hosts anglers on a summer eve. *Credit: C. Gonzalez.*

SOURCES

Including references cited, data sources accessed; not including links to resources, tools, or calls to action, which can be found in the One-Stop-Shop.

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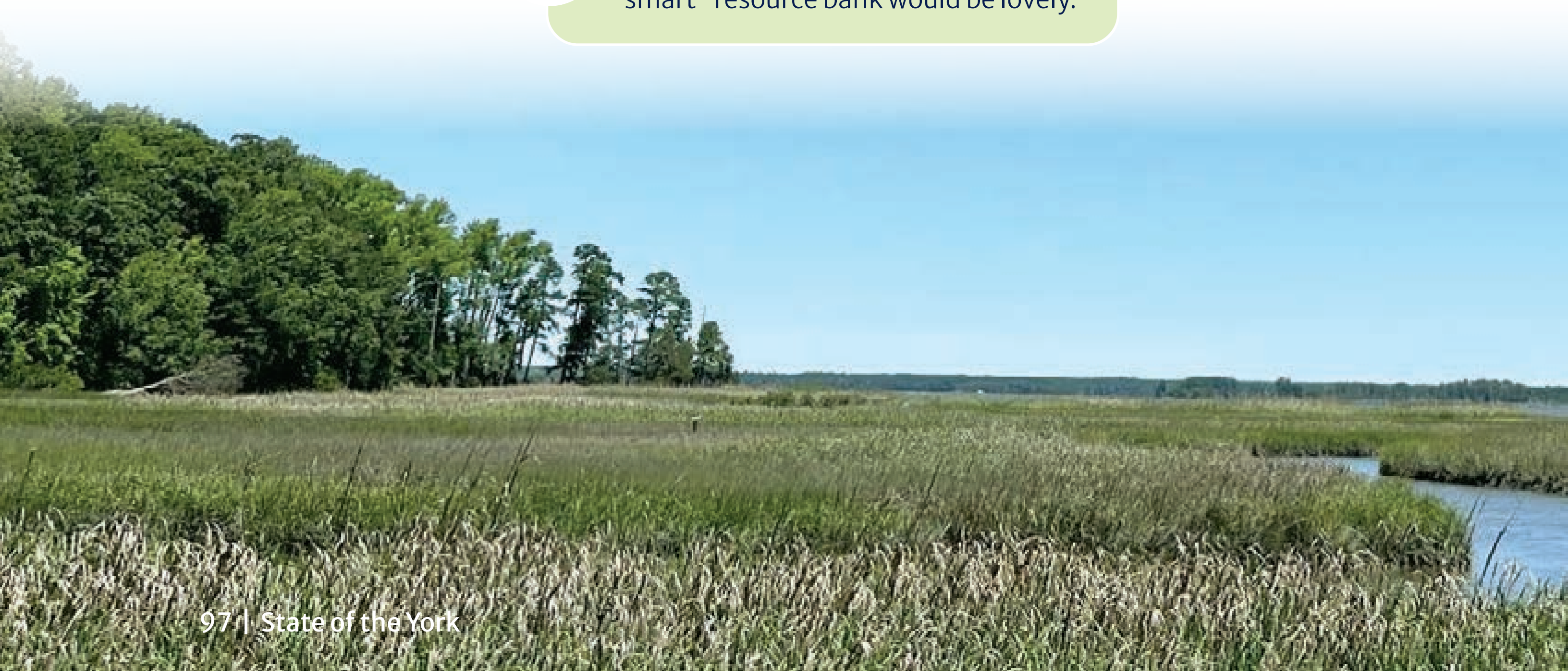
SO much to sift through! Funding for a "smart" resource bank would be lovely.



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View from a hiking trail at York River State Park. *Credit: Susan Stein*

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Sunset at Bayside Landing. *Credit: John Craig Lewis.*

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While our report is interconnected, and many of the below topics are referenced throughout, the following links will connect you to the pages where the topic is of focus and first addressed. Note that subsequent pages may not be referenced or linked; multiple pages are noted for returns to a topic.

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Front photo: Members of the York River and Small Coastal Basin Roundtable kayak with Friends of the Dragon Run. *Credit: CBNERR-VA.*

Back cover photo: Sunset at Beaverdam Park. *Credit: C. Gonzalez.*

Fishing at Haven Beach. *Credit: C. Gonzalez.*